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Tax Incentives, Market Power, and Corporate Investment

A Rational Expectations Model Applied to Pakistani and Turkish Industries

Dagmar Rajagopal
and
Anwar Shah

A production structure model incorporating rational expectations and market power is used to derive important insights on the effectiveness of tax incentives on industrial production and investment decisions in developing countries.

Policy Research

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Financial Policy and Systems

WPS 907

This paper — a product of the Financial Policy and Systems Division, Country Economics Department — is part of a larger effort in the department to explore ways to promote the development of sound securities markets. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Zena Seguis, room N9-005, extension 37664 (May 1992, 32 pages).

In the long run, sound, efficient securities markets can contribute to economic growth; in the short run, they play an important role in financial liberalization and deepening. They do so principally by providing a means for both capital raisers and investors to diversify risk.

Pardy provides a guide to issues involved in institutional and regulatory reform of securities markets — and a discussion of the practical implications of different policy options and sequencing decisions.

Pardy argues that establishing sound securities markets requires institutional development that is a substantial task for many developing countries. Prerequisites for the development of securities markets include:

- A macroeconomic and fiscal environment conducive to the supply of quality securities — as well as sufficient demand for them.

- A legal, regulatory, and institutional infrastructure that can support efficient operation of the securities market.

Pardy discusses the second of these in detail, providing guidelines for basic infrastructural requirements. Essentially such an infrastructure must provide four things:

- Certainty about property rights and contracts.

- Transparent trading and other procedures and public disclosure by companies of all information relevant to the value of their securities.

- Protection against unfair practices by insiders and intermediaries.

- Protection against the financial failure of intermediaries and market institutions such as clearinghouses.

Pardy also provides examples of the policy conflicts and uncertainties that are routine in securities market reform and development, and suggests approaches to managing them.

TAX INCENTIVES, MARKET POWER, AND CORPORATE INVESTMENT

by

Dagmar Rajagopal and Anwar Shah *

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* This is one of a series of discussion papers prepared for the World Bank Research Project, "An Evaluation of Tax Incentives for Industrial and Technological Development". The project is directed by Anwar Shah of the Public Economics Division. The authors are grateful to Gregory Ingram and Nancy Birdsall for helpful comments

1. Introduction

The objective of this paper is to examine the effect of tax incentives on investment in physical capital and in research and development (R&D hereafter), and indirectly on output and the demand for labor and materials. For this purpose we calculate the effect of tax incentives on the rental prices of the services of physical and knowledge capital, and of these rental prices on both types of investment. This paper contains the following major innovations: The first one is the use of rental prices of capital services which are consistent with rational rather than static expectations on the part of economic agents. The second one is that we do not take it for granted that the corporate income tax (CIT hereafter) and hence tax incentives enter the expressions for the rental prices of capital services, but test for their presence in these expressions instead. Usually in empirical studies of particular industries the assumption is maintained that there is perfect competition, so that the possibility of short-run shifting of the CIT does not arise [see e.g. Shah and Baffes (1991)]. We do not maintain this assumption, but test it against the alternative assumption that the firms in a given industry may have market power. If the firms do not exercise their market power fully at the time of a change in the CIT, they may try to shift the CIT on to consumers by raising the price of their output. Even if they try to shift the tax forward in this manner, they may or may not succeed completely in doing so. Instead of ruling out the possibility of complete short-run forward shifting of the CIT a priori, we test for it, as will be explained below. Third, this paper is the first study of its kind for a developing country.

Empirical literature on the developing countries is completely silent on this question, while numerous empirical studies for developed countries have not resulted in a consensus among economists about the incidence of the CIT. Yet it is very important to find out whether the tax does or does not influence the rental prices of capital services. After all, the rental prices of capital services are two of the most important channels through which this tax may or may not influence the production and investment decisions of firms.

It is the short-run impact effect of the CIT which determines whether the tax does or does not have an effect on the rental prices of capital services. This is a question for partial equilibrium analysis. The long-run general equilibrium effects of the tax are quite similar, whether it is shifted in the short run or not. The reason for this is that a tax which is fully shifted forward in the short run results in increased prices of corporate outputs, therefore reduced quantities demanded and produced. The output effect of a fully shifted CIT causes inputs to move from the corporate to the non-corporate sector, which is also the output effect of a CIT that was not shifted in the short run [see Harberger (1962)]. Only the substitution effect of the tax differs, depending on whether it is shifted in the short run or not. It will be shown below that it is the CIT's substitution effect which determines whether the tax enters the expressions for the rental prices of capital services or not.

Pindyck and Rotemberg (1983:1072, footnote 17) commented that the rental price of capital services calculated in the tradition of Christensen and Jorgenson (1969) is not consistent with a rational expectations model, because it embodies static expectations. Here we derive expressions for the rental prices of the services of physical and knowledge capital which are fully consistent with the assumption of rational expectations on the part of economic agents. By "rational expectations" we mean that economic agents use all the information available to them at time s in order to make unbiased forecasts of the values of economic variables that will prevail at a future time t.

The paper goes on to show that the expressions for the rental prices of capital services would be free of the parameters of the CIT if the tax were completely shifted forward in the short run. The fact that the rental prices of capital services depend on the absence or presence of complete short-run forward shifting of the CIT is used as a basis for non-nested hypothesis tests to determine if the tax was fully shifted in the industries studied. (Section 2. provides details on the taxation of corporate income in Pakistan and Turkey.)

A rational-expectations model was estimated twice: Once with expressions for the rental prices of capital services which contain the parameters of the

CIT, the second time with rental prices that are free of tax parameters. The econometric model consists of one equation each for the variable inputs labour and materials, an equation for investment in physical capital, an equation for R&D expenditures (investment in knowledge capital), and an output equation. The factor demand equations and the investment equations were obtained from a quadratic approximation to an arbitrary normalized cost function. Since the quadratic specification is not invariant to the choice of numéraire, the model was estimated twice, using the variable inputs labour and materials as the numéraire input in turn. Non-nested hypothesis tests [on non-nested hypothesis tests see MacKinnon (1983)] were conducted to test the two pairs of expressions for the rental prices of capital services against each other.

For all the industries studied and for both approximations the model using the rental prices of capital services without tax parameters was rejected by the data and the model using the rental prices with tax parameters, whereas the model using the rental prices with tax parameters could not be rejected by the data and the alternative model. For our samples we were thus able to show that the parameters of the CIT do enter the expressions for the rental prices of capital services. Having established this, we went on to calculate the effect of certain tax incentives on output, on the demand for labour and materials, and on investment.

The remainder of the paper proceeds as follows: Section 2. outlines the structure of corporate taxation and of investment incentives in Pakistan and Turkey. The third section presents the theoretical model, with the details of derivations given in appendices (1) to (3). Appendix (4) presents the formulae for the elasticities which were computed, appendix (5) discusses the method of estimation and the non-nested hypothesis tests, while appendix (6) gives the sources for the data and outlines how the variables were constructed from the raw data. Section 4. reports the empirical results, while the last section summarizes the paper and comments on the policy implications of its results.

2. The Structure of Corporate Taxation and Investment Incentives

2.1 Pakistan

Pakistan has followed a stable corporate tax rate regime since the early 1960s. The corporate income tax at 30% and a super tax at 25% have been maintained consistently during the last two decades. Only in the fiscal year 1989-90 the super tax rate was brought down to 15%. Foreign direct investment receives tax treatment equivalent to domestic investment. Losses are allowed to be carried forward six years, but no carryback of such losses is permitted. A sales tax at 12.5% is payable on all domestically manufactured goods by the producer and on imported goods by the importer. In the fiscal year 1989-90, import duties at differential rates were imposed on imported machinery and equipment. These rates varied from 20% to 50% if similar machinery was not manufactured in Pakistan, and a higher rate of 80% applied to imported machinery with domestic substitutes. Businesses were further subject to a large number of miscellaneous licensing fees and charges.

The regime of fiscal incentives through the corporate income tax has experienced significant changes over time. From time to time, Pakistan has relied upon a variety of fiscal incentives to stimulate investment. These include accelerated capital consumption allowances for certain physical assets, full expensing for R&D investments, tax rebates, regional and industry specific tax holidays, and investment tax credits. These are briefly discussed below:

Tax holidays: Tax holidays for two years for specific industries (e.g. engineering goods) and specific regions (most of the country except major metropolitan areas) were introduced in 1959-60. The holiday period was subsequently raised to four years in 1960-61. These tax holidays were eliminated in 1972-73 but reinstated again in 1974-75. Presently tax holidays for five years are permitted to engineering goods, poultry farming and processing, dairy farming, cattle or sheep breeding, fish farming, data processing, industries manufacturing agricultural machinery, and also to all industries in designated areas of the country.

Investment tax credits: Industries are eligible for varying tax credits according to location. A general tax credit for balancing, modernization, and replacement of plant and equipment was introduced at a rate of 15%, but its application was restricted to designated areas. Since 1976-77, the credit was made available regardless of location and type of industry. This credit was withdrawn in 1989-90.

Tax rebates: Companies exporting goods manufactured in Pakistan are entitled to a rebate of 55% of taxes attributable to such sales.

Accelerated capital consumption allowances: Capital consumption allowances follow accelerated schedules for machinery and equipment, transport vehicles and housing for workers (25%), oil exploration equipment (100%), ship building (20-30%), and structures (10%) on a declining balance method. Expenditures relating to research and development, transfer and adaptation of technologies and royalties are eligible for full expensing.

All the pertinent provisions of the tax code including general tax incentives available to the chemical and pharmaceutical industries are embodied in the rental prices of capital services discussed in the following sections.

2.2 Turkey

Corporate tax base and rate: Taxable income of corporate entities (defined as book profits before taxes plus increases in pension reserves and general provision for bad debt minus investment and export allowances and depreciation deductions etc.) is currently taxed at a flat rate of 46%. A 3% defence surcharge is payable on this basic rate. In addition, a 1% tax is payable to the Social Assistance and Security Fund, and an additional 1% tax is levied for the Apprenticeship, Vocational and Training Encouragement Fund, for a combined corporate tax rate of 49.38% . Corporate tax is withheld at source at varying rates with 0% rates for dividend distributions, 5% for income from crude oil exploration, 10% on interest and moveable property income, 20% for income from immoveable property, and 25% for salaries and wages and patents and royalties.

Inventory valuation: Inventories must be valued for tax purposes at their actual historical costs with no adjustment for inflation. If cost cannot be determined on an individual basis, a moving average determination is acceptable.

Capital gains: Capital gains and losses are included in the determination of taxable income.

Dividend distributions: Dividend distributions and intercompany dividends are not taxed.

Depreciation deductions: Depreciation allowances are based on historical costs adjusted by the wholesale price index minus 10% and take the form of ten-year interest bearing bonds. Either the straight-line or declining balance method of depreciation may be chosen for any asset, but no switch is allowed from the straight-line to the declining balance method during the life of the asset. Depreciation on moveable fixed assets acquired on or after January 1, 1983 may be taken under a straight-line method at any rate chosen by the tax payer, up to an annual maximum of 25%. If the declining balance method is used, the maximum allowable depreciation rate is 50%. Assets having values less than 5,000 TL can be deducted. For structures and moveable fixed assets acquired before January 1, 1983, the Ministry of Finance publishes maximum depreciation rates (on a straight-line basis) permissible for tax purposes. These rates typically are 4% for factory buildings, 15% - 20% for transport equipment, and 12.5% for machinery and equipment.

Other taxes: A value-added tax is levied at a general rate of 10%. Banking and insurance transactions are subject to a 3% tax (BITT).

Investment incentives:

Several incentives for investment are available through the tax code. These are discussed below:

a. Investment Incentive Allowance

The investment incentive allowance is a deduction from the taxable income for corporate tax purposes. The deduction is claimed in the year of investment on that portion of investment which is not subsidized by the government. Unused investment allowances can be carried forward indefinitely. The rate of investment allowance varies by region and type of investment as follows:

Region:	
Developed regions	30%
Normal regions	40%
Second priority regions	60%
First priority regions	100%
Priority industries:	100%
Energy	
Electronics and communications	
Medical equipment	
Health, agriculture and animal husbandry	
Tourism and education	
Marine products	
Activity:	
Scientific research and development	100%

b. Special Incentives for Scientific R&D:

In addition to the 100% investment allowance, the following incentives for R&D are also available:

i. Tax postponement: 20% of the amount of corporate tax may be spread in nine equal instalments without interest to three years following the year in which the research and development expenditure is made, provided that the tax so postponed should not exceed the amount of such expenditures made in the corresponding year.

ii. Tax exempt status for corporations carrying out scientific research and development: Effective January 1, 1986, corporations carrying out scientific R&D can apply for tax exempt status.

c. Investment Finance Fund

Corporations can set aside up to 25% of taxable income for future investments. The amount set aside at the discretion of the corporation is deducted from its taxable income and deposited in an interest bearing account (earning the same interest as government bonds, usually about 20% p.a.) with the Central Bank. It can be withdrawn any time with authorization from the State Planning Office and used for investment.

d. Real Estate Tax Exemption

For investments qualifying for investment allowances, real estate taxes are waived for several years.

e. Accelerated Capital Consumption Allowances

As discussed earlier, accelerated depreciations up to a limit of 50% can be claimed for machinery and equipment. Further assets can be revalued at the end of every calendar year.

f. Customs Exemption

Machinery that embodies new technology and improves the international competitiveness of Turkish industries can be imported free of customs duties.

g. Export Allowance

If a company exports industrial goods for more than US$250,000 per year, it can take a 20% deduction of its profits realized on the exports. It the exporter is not the manufacturer of the goods, only a 5% exemption applies.

h. Non-tax Incentives

A large number of non-tax incentives are available to eligible investments. These include low interest credit, funds for working capital, allocation of foreign exchange, and allowance for import of used equipment.

All the pertinent provisions of the tax code are embodied in the rental prices of capital services discussed in the following sections.

3. The Theoretical Model

3.1 Introduction

Two of the main channels through which tax incentives influence the decisions of firms are the rental prices of capital services. Increased tax incentives and lower rental prices of capital services are expected to stimulate investment. Therefore it is important to use the correct expressions for the rental prices of capital services. This paper derives the expressions for the rental prices of the services from physical and knowledge capital from a rational expectations model, which makes them fully consistent with the assumption of rational expectations on the part of economic agents.

Before determining the effect of tax incentives on the rental prices of capital services, it is important to consider another question: What would be the consequence if the firms in a given industry succeeded completely in shifting the CIT forward to consumers by changing the price of output in response to a change in the rate of the CIT?

In a perfectly competitive industry short-run tax shifting, leave apart complete shifting, is of course impossible. Harberger (1962) made the assumption of perfect competition when analyzing the general equilibrium effects of the movement of capital from the corporate to the non-corporate sector because of a change in the CIT. These capital movements result from the changed after-tax rate of return on corporate capital in response to a change in the CIT. Short-run forward shifting of the CIT is not possible either in an industry where firms have some degree of market power, but are exercising this market power fully in order to maximize their short-run profits.

But there may be industries in which firms maximize long-run rather than short-run profits and therefore do not exert their market power fully prior to a change in the CIT. In such an industry the firms might be able to shift the CIT forward completely, so that their after-tax profits would be the same as their profits in the absence of the tax change. In that case there would be no reason for capital to leave the corporate sector, and the Harberger model would not apply. It is more likely that firms with unexerted market power would try to shift the CIT forward, but would succeed only partially in doing so. However, instead of ruling out the possibility of complete tax shifting a priori, we test for the absence or presence of complete short-run tax shifting. We show that a fully shifted CIT would have no effect on the rental prices of the services from physical and knowledge capital, so that tax incentives would be ineffective. It is therefore of great policy relevance to find out whether complete short-run forward shifting of the CIT is as rare in practice as one would expect it to be a priori. This needs to be done for individual industries rather than for the manufacturing sector as a whole, because the preconditions for complete short-run forward shifting of the tax, namely unexerted market power, may well be present in some industries, but absent in others. Since knowing the impact effect of the CIT is so important for policy makers, this topic deserves more attention than it has received so far.

3.2 The rental prices of capital services with partial or no short-run forward shifting of the CIT

Complete short-run forward shifting of the CIT may be impossible for a number of different reasons: The firms of an industry may be price takers in their output markets. They may have market power, but engage in short-run profit maximization. The firms may have some unexerted market power at the time of the tax change, but not enough to be able to pass the CIT on to consumers completely. All these models have in common that a change in the CIT will result in after-tax profits which are lower than profits prior to the tax change. The simplest and therefore most frequently made assumption is that there is perfect competition in an industry. That is the assumption we are going to make in this section. But the expressions for the rental prices of capital services would be the same under any of the other assumptions about market structure and firm behavior mentioned above.

The assumption of rational expectations implies that firms view future prices and quantities as realizations of stochastic variables. Based on the information available to them at the present time s, they form expectations about prices and quantities at the times t, $t = s, s+1, \ldots \infty$. For example, the notation $\epsilon_s\{K_t\}$ refers to the mathematical expectation of K_t, conditional on Ω_s, the set of information available at time s. The subjective expectations of economic agents are assumed to be equal to this mathematical expectation $\epsilon_s\{K_t\}$.

The general model presented here encompasses the models we actually estimated as three special cases. We point out the differences between these special cases whenever appropriate.

The firm is assumed to maximize the expected value of the stream of its discounted future dividends in excess of the opportunity cost of equity capital, i.e. its expected net present value. The firm's objective function is therefore given by:

$$(1)\quad V = e_s \sum_{t=s}^{\infty} D_{s,t}\{(P_{yt})(Y_t) - \sum_{j=1}^{2}(W_{jt})(v_{jt}) - (i_{t,t+a})(A_t) - (u_{pt})(K^{\&}_{pt}) - (P_{\ell t})(I_{pt}) - (P_{kt})(I_{kt}) + DA_{t+1} - CITP_t\}$$

Discrete rather than continuous time is used in this model. Therefore the net present value of the firm is a sum rather than an integral, and the discount factor is $D_{s,t} =$

$$\frac{1}{(1+r_{s,t})(1+\pi_{s,t})} = \frac{1}{1+r_{s,t}+\pi_{s,t}+\underbrace{(r_{s,t})(\pi_{s,t})}_{\doteq\, 0}} = \frac{1}{(1+i_{s,t})},$$

rather than $e^{-(r+\pi)t} = e^{-it}$. Here $r_{s,t}$, $i_{s,t}$ and $\pi_{s,t}$ denote the real interest rate, nominal interest rate and rate of inflation which prevail between the current time period s and the future time period t. The other variables in the equation for the expected net present value of the firm are defined as follows, where the time subscript has been omitted from some of the variables for ease of notation:

P_{yt} = $(p_{yt})(1 + \pi_{0,t})$ = price of output in nominal terms

p_{yt} = real price of output

Y = quantity of output

W_{jt} = $(w_{jt})(1 + \pi_{0,t})$ = nominal price of variable input j, j = L,M

w_{jt} = real price of variable input j

v_j = quantity of variable input j

A = firm's debt + equity

a = average time period for which A is outstanding at time t

u_p = property tax rate

K_p^{a} = assessed value of those of the firm's physical assets which are subject to the property tax. It is assumed here that assessment of properties takes place at infrequent intervals, so that the assessed value K_p^{a} is independent of the firm's true stock of physical capital K_p, and of its physical capital stock K_p^{*} for the purposes of the CIT.

P_{pt} = $(p_{pt})(1 + \pi_{0,t})$ = nominal price of physical investment goods

p_{pt} = real price of physical investment goods

P_{kt} = $(p_{kt})(1 + \pi_{0,t})$ = nominal price of expenditures on R&D

p_{kt} = real price of expenditures on R&D

I_p = amount of gross investment in physical capital

I_k = amount of gross investment in knowledge capital, i.e. amount of R&D

DA_{t+1} = $A_{t+1} - A_t$ = new debt and equity issued during period t

$CITP_t$ = corporate income tax payments at time t, defined by:

$$CITP_t = (u_{ct})[(P_{yt})(Y_t) - \sum_{j=1}^{2}(W_{jt})(v_{jt}) - (b_t)(i_{t,t+a})(A_t) - (u_{pt})(K_{pt}^{a})$$
$$- (\alpha_{kt})(P_{kt})(K_{kt}^{*}) - (\alpha_{pt})(P_{pt})(K_{pt}^{*}) - (q_{kt})(P_{kt})(I_{kt})$$
$$- (q_{pt})(P_{pt})(I_{pt})] - (m_{pt})(P_{pt})(I_{pt}), \text{ where:}$$

u_c = statutory rate of the CIT

b = ratio of debt to the sum of debt and equity A

α^k = rate of depreciation of knowledge capital allowed by the CIT in Turkey

α_p = rate of depreciation of physical capital allowed by the CIT in Pakistan as well as in Turkey

K_k^* = stock of knowledge capital for the purposes of the CIT, relevant only for Turkey

K_p^* = physical capital stock for the purposes of the CIT, relevant for both countries

q_k = proportion of R&D expenditures which firms are allowed to expense, i.e. to deduct from revenue in the year in which they have been incurred, in both countries

q_p = proportion of investment in physical capital which firms are allowed to expense, only in Turkey

m_p = rate of tax credit granted by the CIT for investment in physical capital, only in Pakistan

We estimated three different models, which are special cases of the above general model. Our Turkish sample consists of the chemical and petroleum derivatives industries. For Pakistan we have two samples: the larger one contains data for the chemical and pharmaceutical industries, the smaller one is limited to one industry, the textile industry. For our two larger samples we were able to estimate the complete model, although the different tax structures of the two countries made two separate models necessary. For the Pakistani textile industry we were able to include only one of the two capital stocks in the model, since this sample is too small for the number of parameters which have to be estimated for the complete model. Therefore, for the Pakistani textile industry we have $I_{kt} = K_{kt} = P_{kt} = K_k^* = 0$, where K_{kt} is the true stock of knowledge capital at the beginning of period t.

The firm's production function is given by:

(2) $Y_t = Y_t(v_{jt}, K_{pt}, K_{kt}, I_{pt}, I_{kt}, t)$,

where Y_t is the quantity of output, v_{jt} is a (1x2)-vector of variable inputs, K_{pt} is the true stock of physical capital at the beginning of period t, and time t as usual serves as a proxy for technological change. The production function indicates that output Y depends on the variable inputs v_j, on the quasi-fixed inputs K_p and K_k, on technological change, and on gross investment in physical and knowledge capital. The fact that both kinds of investment are arguments in the production function implies the assumption that the firm is subject to internal, non-separable adjustment costs caused by investment in physical as well as knowledge capital. [See Treadway (1970) and (1974) on the desirability of specifying adjustment costs as internal and non-separable.]

It is assumed that lenders do not allow the firm's dividends in excess of the cost of equity capital to be greater than its after-tax economic profits. This condition is represented by the following inequality:

$$(3)\quad (P_{yt})(Y_t) - \sum_{j=1}^{2}(W_{jt})(v_{jt}) - (i_{t,t+a})(A_t) - (u_{pt})(K_{pt}^{\&}) - (P_{pt})(I_{pt}) -$$
$$(P_{kt})(I_{kt}) + DA_{t+1} - CITP_t \le (P_{yt})(Y_t) - \sum_{j=1}^{2}(W_{jt})(v_{jt}) - (i_{t,t+a})(A_t)$$
$$- (u_{pt})(K_{pt}^{\&}) - \delta_p(P_{pt})(K_{pt}) - \delta_k(P_{kt})(K_{kt}) - CITP_t,$$

where δ_p = economic rate of depreciation of physical capital,

δ_k = economic rate of depreciation of knowledge capital.

Since optimality requires this inequality to be strictly binding [see Boadway and Bruce (1979)], it can be re-written as the following borrowing constraint [after some simplifications, see appendix (1)]:

(4) $DA_{t+1} = (P_{pt+1})(K_{pt+1}) - (P_{pt})(K_{pt}) + (P_{kt+1})(K_{kt+1}) - (P_{kt})(K_{kt})$

Appendix (2) derives the following investment equation in terms of the stock of physical capital K_p^* and the rate of depreciation α_p for purposes of the CIT:

$$(5) \quad (P_{pt})(I_{pt}) = (\alpha_{pt})(P_{pt})(K_{pt}^*) + (P_{pt+1})(K_{pt+1}^*) - (P_{pt})(K_{pt}^*)$$

The following investment constraint for physical capital is obtained by substituting the sum of replacement investment and net investment into the left-hand side of (5):

$$(6) \quad \delta_p(P_{pt})(K_{pt}) + (P_{pt+1})(K_{pt+1}) - (P_{pt})(K_{pt}) = (\alpha_{pt})(P_{pt})(K_{pt}^*) + (P_{pt+1})(K_{pt+1}^*) - (P_{pt})(K_{pt}^*)$$

An analogous investment constraint for knowledge capital is given by:

$$(7) \quad \delta_k(P_{kt})(K_{kt}) + (P_{kt+1})(K_{kt+1}) - (P_{kt})(K_{kt}) = (\alpha_{kt})(P_{kt})(K_{kt}^*) + (P_{kt+1})(K_{kt+1}^*) - (P_{kt})(K_{kt}^*)$$

Substituting for gross investment in physical and knowledge capital in objective function (1), augmenting it by production function (2), borrowing constraint (4) and investment constraints (6) and (7), one obtains the following Lagrangean:

$$\begin{aligned}(8) \quad L = e_s \sum_{t=s}^{\infty} D_{s,t}\{ & (P_{yt})(Y_t) - \sum_{j=1}^{2}(W_{jt})(v_{jt}) - (i_{t,t+a})(A_t) - (u_{pt})(K_{pt}^*) \\ & - \delta_p(P_{pt})(K_{pt}) - (P_{pt+1})(K_{pt+1}) + (P_{pt})(K_{pt}) \\ & - \delta_k(P_{kt})(K_{kt}) - (P_{kt+1})(K_{kt+1}) + (P_{kt})(K_{kt}) + DA_{t+1} - CITP_t \\ & - k_3[Y_t - Y_t(v_{jt}, K_{pt}, K_{kt}, I_{pt}, I_{kt}, t)] \\ & - k_2[DA_{t+1} - (P_{pt+1})(K_{pt+1}) + (P_{pt})(K_{pt}) - (P_{kt+1})(K_{kt+1}) + (P_{kt})(K_{kt})] \\ & - k_1[\delta_p(P_{pt})(K_{pt}) + (P_{pt+1})(K_{pt+1}) - (P_{pt})(K_{pt}) - (\alpha_{pt})(P_{pt})(K_{pt}^*) \\ & - (P_{pt+1})(K_{pt+1}^*) + (P_{pt})(K_{pt}^*)] \\ & - k_4[\delta_k(P_{kt})(K_{kt}) + (P_{kt+1})(K_{kt+1}) - (P_{kt})(K_{kt}) - (\alpha_{kt})(P_{kt})(K_{kt}^*) \\ & - (P_{kt+1})(K_{kt+1}^*) + (P_{kt})(K_{kt}^*)]\},\end{aligned}$$

where k_1 to k_4 are Lagrangean multipliers.

It is convenient to think of the firm's optimization problem as consisting of three separate decisions, although in practice these decisions may well be taken simultaneously. The first step is to chose the least-cost combination of inputs, given a specific quantity of output, and given the existing stocks of physical and knowledge capital. The next step is to determine the optimal quantity of output, still assuming the capital stocks to be constant. At the final stage of the decision making process the firm chooses the optimal rates of change of its stocks of physical and knowledge capital.

The optimal input quantities $v_j^{\#}$ are found as follows: At time t

Lagrangean (8) is differentiated partially with respect to inputs v_{1t} and v_{2t}, the derivatives are set equal to zero and the first equation is divided by the second one. Since at time t the variables of the same period are known with certainty, the expectations operator is unnecessary, and the discount factor $D_{t,t} = 1$. Therefore we get the well-known result $w_{1t}/w_{2t} = MPP_1/MPP_2$, where MPP stands for marginal physical product. This equation implicitly defines the optimal input quantities as functions of the following variables:

(9) $v_{jt}^{\#} = v_{jt}^{\#}(w_{jt}, Y_t, K_{pt}, K_{kt}, I_{pt}, I_{kt}, t)$

Then the minimum variable cost functions in real and in nominal terms are given by:

(10) $\sum_{j=1}^{2} (v_{jt}^{\#})(w_{jt}) = g_t^{\#}(w_{jt}, Y_t, K_{pt}, K_{kt}, I_{pt}, I_{kt}, t)$ *and*

(11) $\sum_{j=1}^{2} (v_{jt}^{\#})(W_{jt}) = G_t^{\#}(\pi_{o,t}, w_{jt}, Y_t, K_{pt}, K_{kt}, I_{pt}, I_{kt}, t) = (1 + \pi_{o,t})(g_t^{\#})$

The cost function is increasing, continuous, concave and linearly homogeneous in the two input prices, increasing in output and decreasing in investment in physical and knowledge capital. From duality theory we know that the cost function incorporates all the information about the firm's technological structure which is contained in its production function. In particular, the presence of I_{pt} and I_{kt} as arguments in (10) and (11) indicates that the firm is subject to internal, non-separable adjustment costs. After the cost function has been incorporated into Lagrangean (8), the production function is no longer necessary as a separate constraint.

The next stage of the optimization process is to choose the optimal quantity $Y_t^\#$ of output. Differentiating the Lagrangean partially with respect to Y_t and setting the derivative equal to zero, we obtain the following first-order condition, in which again all variables are known with certainty, and the discount factor $D_{t,t} = 1$:

$$(12) \quad (T_{ct})(P_{yt}) - T_{ct}\frac{\partial G_t^\#}{\partial Y_t^\#} = 0, \ where\ T_{ct} = 1 - u_{ct}.$$

Dividing both sides of (12) by T_{ct} results in the well-known first-order condition P = MC.

Equation (12) implicitly defines optimal output $Y_t^\#$ as a function of the price of output and of the variables which determine the minimum variable cost function:

$$(13) \quad Y_t^\# = Y_t^\# \, (P_{yt},\ W_{jt},\ K_{pt},\ K_{kt},\ I_{pt},\ I_{kt},\ t)$$

The final step is to determine the firm's optimal stocks of physical capital $K_p^\#$ and of knowledge capital $K_k^\#$ for the time period (t+1). Incorporating the cost function and the optimal level of output $Y_t^\#$ into Lagrangean (8) and combining terms, the latter becomes:

$$(14)\quad L = \epsilon_s \sum_{t=s}^{\infty} D_{s,t}\{T_{ct}[(P_{yt})(Y_t^{\#}(\cdot)) - G_t^{\#}(\cdot) - (b_t)(i_{t,t+a})(A_t) - (u_{pt})(K_{pt}^{*})]$$

$$- (1 - b_t)(i_{t,t+a})(A_t) + DA_{t+1} + (u_{ct})(\alpha_{kt})(P_{kt})(K_{kt}^{*})$$

$$+ (u_{ct})(\alpha_{pt})(P_{pt})(K_{pt}^{*})$$

$$- [1 - (u_{ct})(q_{kt})][(\delta_k)(P_{kt})(K_{kt}) + (P_{kt+1})(K_{kt+1}) - (P_{kt})(K_{kt})]$$

$$- [1 - (u_{ct})(q_{pt}) - (m_{pt})][(\delta_p)(P_{pt})(K_{pt}) + (P_{pt+1})(K_{pt+1}) - (P_{pt})(K_{pt})]$$

$$- k_2[DA_{t+1} - (P_{pt+1})(K_{pt+1}) + (P_{pt})(K_{pt}) - (P_{kt+1})(K_{kt+1}) + (P_{kt})(K_{kt})]$$

$$- k_1[\delta_p(P_{pt})(K_{pt}) + (P_{pt+1})(K_{pt+1}) - (P_{pt})(K_{pt}) - (\alpha_{pt})(P_{pt})(K_{pt}^{*})$$

$$- (P_{pt+1})(K_{pt+1}^{*}) + (P_{pt})(K \quad]$$

$$- k_4[\delta_k(P_{kt})(K_{kt}) + (P_{kt+1} \quad _{t+1}) - (P_{kt})(K_{kt}) - (\alpha_{kt})(P_{kt})(K_{kt}^{*})$$

$$- (P_{kt+1})(K_{kt+1}^{*}) + (P_{kt})(K_{kt}^{*})]\}$$

Differentiating (14) with respect to the control variables A_{t+1}, K^{*}_{pt+1}, K^{*}_{kt+1}, K_{pt+1} and K_{kt+1}, setting the derivatives equal to zero and solving the resulting system of equations, yields the following two optimality conditions [for details of these calculations see appendix (3)]:

$$(15)\quad \frac{-1}{1+r_{t,t+1}}\,\epsilon_t\{\frac{\partial g^{\#}_{t+1}}{\partial K^{\#}_{pt+1}}\} - \frac{T_{ct}}{\epsilon_t\{T_{ct+1}\}}\,\frac{\partial g^{\#}_t}{\partial I^{\#}_{pt}} + \frac{(1-\delta_p)}{1+r_{t,t+1}}\,\epsilon_t\{\frac{\partial g^{\#}_{t+1}}{\partial I^{\#}_{pt+1}}\} =$$

$$\frac{1}{1+r_{t,t+1}}\,\frac{\epsilon_t\{p_{pt+1}\}}{\epsilon_t\{T_{ct+1}\}}\,[\epsilon_t\{i_{t+1,t+1+a}\}(1 - \epsilon_t\{b_{t+1}\}\epsilon_t\{u_{ct+1}\}) + \delta_p] -$$

$$(1+\pi_{t,t+1})\,\frac{\epsilon_t\{p_{pt+1}\}}{\epsilon_t\{T_{ct+1}\}}\,(m_{pt}) + \frac{(1-\delta_p)}{1+r_{t,t+1}}\,\frac{\epsilon_t\{p_{pt+1}\}}{\epsilon_t\{T_{ct+1}\}}\,\epsilon_t\{m_{pt+1}\} -$$

$$(1+\pi_{t,t+1})\,\frac{\epsilon_t\{p_{pt+1}\}}{\epsilon_t\{T_{ct+1}\}}\,(q_{pt})(u_{ct}) + \frac{(1-\delta_p)}{1+r_{t,t+1})}\,\frac{\epsilon_t\{p_{pt+1}\}}{\epsilon_t\{T_{ct+1}\}}\,\epsilon_t\{q_{pt+1}\}\,\epsilon_t\{u_{ct+1}\}$$

$$- \frac{\epsilon_t\{p_{pt+1}\}(i_{t,t+1} + \delta_p)\epsilon_t\{\alpha_{pt+1}\}\epsilon_t\{u_{ct+1}\}}{\epsilon_t\{T_{ct+1}\}(1+r_{t,t+1})(i_{t,t+1} + \epsilon_t\{\alpha_{pt+1}\})}$$

$$(16)\quad \frac{-1}{1+r_{t,t+1}}\,\epsilon_t\{\frac{\partial g^{\#}_{t+1}}{\partial K^{\#}_{kt+1}}\} - \frac{T_{ct}}{\epsilon_t\{T_{ct+1}\}}\,\frac{\partial g^{\#}_t}{\partial I^{\#}_{kt}} + \frac{(1-\delta_k)}{1+r_{t,t+1}}\,\epsilon_t\{\frac{\partial g^{\#}_{t+1}}{\partial I^{\#}_{kt+1}}\} =$$

$$\frac{1}{1+r_{t,t+1}}\,\frac{\epsilon_t\{p_{kt+1}\}}{\epsilon_t\{T_{ct+1}\}}\,[\epsilon_t\{i_{t+1,t+1+a}\}(1 - \epsilon_t\{b_{t+1}\}\epsilon_t\{u_{ct+1}\}) + \delta_k] -$$

$$(1+\pi_{t,t+1})\,\frac{\epsilon_t\{p_{kt+1}\}}{\epsilon_t\{T_{ct+1}\}}\,(q_{kt})(u_{ct}) + \frac{(1-\delta_k)}{1+r_{t,t+1}}\,\frac{\epsilon_t\{p_{kt+1}\}}{\epsilon_t\{T_{ct+1}\}}\,\epsilon_t\{q_{kt+1}\}\,\epsilon_t\{u_{ct+1}\}$$

$$- \frac{\epsilon_t\{p_{kt+1}\}(i_{t,t+1} + \delta_k)\epsilon_t\{\alpha_{kt+1}\}\,\epsilon_t\{u_{ct+1}\}}{\epsilon_t\{T_{ct+1}\}(1+r_{t,t+1})(i_{t,t+1} + \epsilon_t\{\alpha_{kt+1}\})}$$

The left-hand side of (15) represents the expected discounted marginal benefit from increasing the stock of physical capital, reduced by adjustment costs incurred in the current period, but increased by the adjustment costs saved in the next period by investing in the current period instead. In short, the left-hand side of the optimality condition represents the expected discounted after-tax net marginal benefit from increasing the stock of physical capital. The right-hand side of (15) represents the rental price of the services from physical capital in the absence of full shifting of the CIT, denoted $rp_{pt}(tax)$. The stock of physical capital K_{pt+1} for the next period is chosen optimally if the expected discounted after-tax net marginal benefit from investment in physical capital is equal to $rp_{pt}(tax)$, the rental price of the services from physical capital.

The Turkish CIT does not give an investment credit for physical investment. Therefore the terms involving m_{pt} and m_{pt+1} on the right-hand side of (15) are equal to zero. In Pakistan, on the other hand, the CIT does not allow any part of investment expenditures to be expensed, so that for Pakistan the terms containing q_{pt} and q_{pt+1} vanish.

The left-hand side of (16) represents the expected discounted after-tax marginal benefit from increasing the stock of knowledge capital net of the adjustment costs incurred by engaging in research and development. The right-hand side of (16) represents the rental price of the services from knowledge capital in the absence of full shifting of the CIT, denoted $rp_{kt}(tax)$. The capital stock K_{kt+1} for the next period is chosen optimally if the expected discounted after-tax net marginal benefit from investment in knowledge capital is equal to $rp_{kt}(tax)$, the rental price of the services from knowledge capital.

In Pakistan the CIT does not allow accelerated depreciation for knowledge capital, α_{kt+1} is equal to zero, and the last term on the right-hand side of (16) vanishes. Since the model of the Pakistani textile industry contains neither R&D nor knowledge capital, equation (16) is irrelevant for that model.

The rental prices of capital services defined by (15) and (16) are fully consistent with rational expectations on the part of economic agents. They are forward looking in the sense that they take into account not only the current parameters of the CIT, but those for the next period as well. Optimality conditions (15) and (16) also incorporate the effect of investment in the following period, which in turn is partly determined by the tax parameters for the next period and the one after that. In this way (15) and (16) indirectly link all future time periods to the present investment decision.

It is worth noting that the expected average cost of debt and equity capital $\epsilon_t\{i_{t+1,t+1+a}\}$ occurs in the expressions for the rental prices of the services from physical and knowledge capital. While the current rate of inflation has no effect on the rental prices of capital services, the rate of inflation expected to prevail over the average lifetime of the dominant firm's debt and equity capital at time t+1 does influence the rental prices of capital services. By increasing these rental prices, expected future inflation reduces the firm's optimal stocks of physical and knowledge capital.

Inspection of equation (15) shows that an increase in this period's investment tax credit m_{pt} has the effect of reducing the rental price of the services from physical capital, while an expected increase in m_{pt+1}, the tax credit for the next period, increases this rental price, other things being equal. Similarly, an increase in this period's investment allowance q_{pt} has the effect of reducing the rental price of the services from physical capital, which is presumably the effect intended by policy makers. Increased investment allowances expected for the next period, on the other hand, raise the rental price of the services from physical capital ceteris paribus. It does make sense that firms face a higher rental price of capital services and hence invest less during the current period if they expect the tax climate to become more favourable to them in the next period.

Inspection of equation (16) reveals that, in general, a small increase in the fraction q_{kt} of a firm's expenditures on R&D which it is allowed to treat as expenses, reduces the rental price of the services from knowledge capital, presumably the effect intended by policy makers. An expected increase of q_{kt+1}, the allowed rate of expensing of R&D expenditures for the next time period, increases the rental price of the services from knowledge capital, which agrees with intuition. In the case of Pakistan, however, firms are allowed to treat the full amount of R&D as expenditures in the year in which they are incurred. Therefore $q_{kt} = 1$, and it cannot be increased beyond 1. To examine the effect of full expensing of R&D expenditures, we have to ask therefore what would happen if q_{kt} were reduced by a small amount. As equation (16) shows, this would increase the rental price of the services from knowledge capital. If the expected rate of expensing q_{kt+1} were reduced, however, the rental price of the services from knowledge capital would fall.

It is easy to show [by differentiating the right-hand side of (15) partially with respect to $\epsilon_t\{\alpha_{pt+1}\}$ and the right-hand side of (16) with respect to $\epsilon_t\{\alpha_{kt+1}\}$] that an increase in the expected rate of accelerated depreciation will reduce the rental prices of the services from physical and knowledge capital, which will stimulate investment in both types of capital. This agrees with what intuition predicts.

In this section the assumption was made that the firm is not able to pass the burden of the CIT on to consumers by increasing the price of its output. Under this assumption the CIT initially reduces the firm's after-tax profit, and capital leaves the corporate for the non-corporate sector, as analyzed in Harberger (1962). In the next section the assumption will be made that full short-run forward shifting of the CIT does take place, i.e. that firms succeed in raising the prices of their outputs in such a way that their after-tax profits are equal to their profits prior to the tax change. In that case there would be no incentive for capital to move from the corporate to the non-corporate sector because of lower after-tax profits (substitution effect). But even then the CIT would have an output effect, since higher output prices would be accompanied by lower quantities of output, so that the corporate sector's demand for all factors of production, including capital, would fall. That is why the long-run, general equilibrium effects of the CIT are quite similar in the absence or presence of complete short-run forward shifting of the tax. But it will be shown in the next section that the expressions for the rental prices of physical and knowledge capital differ depending on the impact effect of the CIT on after-tax profits, and that the impact effect in turn depends on whether the tax is or is not fully shifted forward in the short run.

To some readers it may seem obvious that a fully shifted CIT, i.e. one which leaves after-tax profits at the level of profits in the absence of the tax (change), will not have any effect on the rental prices of capital services. Such readers may want to omit the following section. However, what is intuitively obvious to some may be difficult to accept for others. Besides, if the connection between full short-run forward shifting of the CIT and the expressions for the rental prices of capital services were perfectly obvious, it would surely have been mentioned in the literature by now. To our knowledge such a connection has never been made. That is why in section 3.3 a rigorous proof is given that a fully shifted CIT has no effect on the rental prices of the services from physical or knowledge capital.

3.3 <u>The user cost of capital when complete short-run forward shifting of the CIT is assumed</u>

Complete short-run forward shifting of the CIT is possible only if the firms of a particular industry have market power, and if they do not fully exercise their market power prior to a change in the CIT. Unexerted market power may exist for a variety of reasons. Here the assumption is made that prior to the tax change a dominant firm (or group of dominant firms acting as if they were one firm) trades off higher short-run profit for a larger market share and therefore produces more than the output at which short-run profit is maximized. There are reasons other than limit pricing why a firm may not want to exert its market power to the fullest possible extent. Limit pricing is assumed here not because it is likely to be a widespread practice, but because it can be most easily incorporated into an intertemporal optimization framework. The effect of complete short-run forward shifting of the CIT on the rental prices of capital services is the same, regardless of the conditions which make full tax shifting possible.

We first examine the case of a limit pricing firm in the absence of the CIT. The purpose of that discussion is to demonstrate that the optimal output of a firm which practises limit pricing in order to maximize its long-run profits is larger than the optimal output of a firm which maximizes short-run profits. For such a firm there is scope for a reduction in output, therefore, in response to the imposition of the CIT. In the second part of this section we derive the rental prices of capital services under the assumption that the CIT is shifted forward completely in the short run.

In the absence of the CIT the firm's net present value is obtained by setting $CITP_t = 0$ in equation (1) above. We number this objective function without CIT-payments equation (1'). Industry demand Y^I is assumed to depend on income X and the price P_{ys} of substitute goods. By definition, industry demand Y_t^I is the sum of the demand Y_t for the output of the dominant firm, and of the demand R_t for the output of rival firms:

(17) $Y_t^I(X, P_{ys}) = Y_t + R_t$

If R_t is equal to zero, the dominant firm practices limit pricing in order to deter entry by potential rivals. If R_t is positive, the firm practices limit pricing in order to prevent the output of the industry's competitive fringe from growing faster than is optimal from the point of view of the dominant firm. The dominant firm is assumed to be subject to the following entry constraint at the time of the change in the CIT:

(18) $DR_{t+1}\ (= R_{t+1} - R_t) = c_t(Y_t^{\&} - Y_t)$

where $Y_t^{\&}$ is that output of the dominant firm at which there is no change in the output R_t of rival firms, and $c_t \geq 0$ is a reaction coefficient. A similar constraint can be found in Gaskins Jr. (1971), except that there continuous rather than discrete time was used, and a non-entry price rather than a non-entry output. This entry constraint implies that the output of rival firms will increase if the dominant firm reduces its own output Y_t below the non-entry output Y_t^e. Production function (2) and borrowing constraint (4) are the same as above. The derivation of the minimum variable cost function (11) proceeds exactly as in section 3.2 above, so there is no need to repeat it here.

We incorporate minimum variable cost function (11) into objective function (1'), augment it by borrowing constraint (4) and entry constraint (18), thereby obtaining the following Lagrangean:

$$
\begin{aligned}
(19)\quad L = e_s \sum_{t=s}^{\infty} D_{s,t}\{ &(P_{yt})(Y_t) - G_t^o(\cdot) - (i_{t,t+a})(A_t) - (u_{pt})(K_t^e) \\
&- (P_{pt})(I_{kt}) - (P_{kt})(I_{kt}) + DA_{t+1} \\
&- k_2[DA_{t+1} - (P_{pt+1})(K_{pt+1}) + (P_{pt})(K_{pt}) - (P_{kt+1})(K_{kt+1}) + (P_{kt})(K_{kt})] \\
&- k_4[DR_{t+1} - c_t(Y_t^e - Y_t)]\},
\end{aligned}
$$

where the superscript "o" denotes optimality in the situation without any CIT.

Differentiating (19) with respect to output, setting the derivative equal to zero and denoting the optimal output by Y_t^o, we obtain the following first-order condition:

$$
(20)\quad [Y_t^o \frac{(dP_{yt})}{dY_t^I} \underbrace{\left(\frac{dY_t^I(X_t, P_{yst})}{dY_t^o}\right)}_{=1\ by\ (17)} + P_{yt} - \frac{\partial G_t^o}{\partial Y_t^o}] - k_4 c_t = 0
$$

In (20) P_{yt} is not a constant, since we do not assume perfect competition in this section. Equation (20) in effect boils down to the condition that in equilibrium MR = MC + k_4c_t. We are interested in examining the sign of the term k_4c_t. The reaction coefficient c_t is a non-negative constant by assumption. So we need to determine only the sign of k_4. The Lagrangean multiplier k_4

represents the contribution of DR_{t+1} to the objective function. Since the net present value of the firm will ceteris paribus be reduced by an increase in the output of rival firms, k_4 is negative. The term k_4c_t is therefore negative and has the same effect on the firm's optimal output which a reduction in MC would have: it increases output above the level which would be optimal in the absence of limit pricing. We have therefore shown that there is scope for a limit pricing firm to reduce its output in response to the imposition of the CIT.

Next we derive the rental prices of capital services under the assumption that the firm is able to shift the CIT forward completely in the short run. We are not claiming that complete short-run shifting of the CIT is likely to occur in many industries, perhaps it never happens. We are simply asking the question: What would the expressions for the rental prices of capital services be if the firms in a particular industry were completely successful in shifting the CIT forward in the short run.

After the change in the CIT the dominant firm is assumed to reduce its output and increase its price in such a way that its after-tax profit is equal to its profit prior to the tax change, the definition of full shifting. In other words, the dominant firm is assumed to succeed completely in passing the CIT on to the consumers of its products. This assumption is captured in shifting equation (21) introduced below.

The objective function is given by equation (1) above, and the borrowing constraint by (4). The entry constraint is the same as (18) in the absence of the CIT, except that we denote the non-entry output in the situation of full short-run shifting as Y_t^*. Since the least-cost combination is independent of whether full tax shifting does or does not take place, the derivation of the firm's minimum variable cost function $G_t^\#$ (fs) ["fs" stands for full shifting] is the same as the derivation of $G_t^\#$ above, and $G_t^\#$ (fs) can be incorporated into the objective function immediately. After the cost-minimizing combination of inputs has been determined, the dominant firm is assumed to choose its optimal quantity of output in such a way as to make its after-tax profit equal to its profit prior to the tax change, as stated in equation (21):

$$(21)\quad (P_{yt})(Y_t) - G_t^{\#}(fs)(\cdot) - (i_{t,t+a})(b_t)(A_t) - (u_{pt})(K_t^{*}) - \delta_p(P_{pt})(K_{pt}) - \delta_k(P_{kt})(K_{kt}) - CITP_t = (P_{yt})(Y_t^{o}) - G_t^{o}(\cdot) - (i_{t,t+a})(b_t)(A_t) - (u_{pt})(K_t^{*}) - \delta_p(P_{pt})(K_{pt}) - \delta_k(P_{kt})(K_{kt}),$$

where Y_t^o and G_t^o are the firm's optimal output and minimum variable cost

function prior to the imposition of the CIT. Augmenting the objective function (1) by borrowing constraint (4), entry constraint (18) and shifting assumption (21), we obtain the following Lagrangean:

$$\begin{aligned}(22)\quad L = e_s \sum_{t=s}^{\infty} D_{s,t}\{ & (P_{yt})(Y_t) - G_t^{\#}(fs)(\cdot) - (i_{t,t+a})(A_t) - (u_{pt})(K_t^{*}) \\ & - (P_{pt})(I_{pt}) - (P_{kt})(I_{kt}) + DA_{t+1} - CITP_t \\ & - k_2[DA_{t+1} - (P_{pt+1})(K_{pt+1}) + (P_{pt})(K_{pt}) - (P_{kt+1}(K_{kt+1} + (P_{kt})(K_{kt})] \\ & - k_6[DR_{t+1} - c_t(Y_t^{*} - Y_t)] \\ & - k_5[(P_{yt})((Y_t) - G_t^{\#}(fs)(\cdot) - (i_{t,t+a})(b_t)(A_t) - (u_{pt})(K_t^{*}) \\ & - \delta_p(P_{pt})(K_{pt}) - \delta_k(P_{kt})(K_{kt}) - CITP_t \\ & - (P_{yt})(Y_t^{o}) + G_t^{o}(\cdot) + (i_{t,t+a})(b_t)(A_t) + (u_{pt})(K_t^{*}) \\ & + \delta_p(P_{pt})(K_{pt}) + \delta_k(P_{kt})(K_{kt})]\}\end{aligned}$$

Differentiating (22) with respect to Y_t and setting the derivative equal to zero, we obtain the following first-order condition:

$$(23)\quad T_{ct}\,[Y_t^{\#}(fs)\,\frac{dP_{yt}}{dY_t^{I}}\,\underbrace{\frac{dY_t^{I}(X_t,P_{yst})}{dY_t^{\#}(fs)}}_{=1\ by\ (17)} + P_{yt} - \frac{\partial G_t^{\#}(fs)}{\partial Y_t^{\#}(fs)}](1-k_5) - k_4 c_t = 0$$

In the absence of the CIT $k_5 = 0$ and $T_{ct} = 1$, and if the dominant firm does not use limit pricing to deter entry, $k_4 = 0$ as well. In that case equation (23) reduces to the well-known equilibrium condition MR = MC, and the dominant firm maximizes its short-run profits.

When the dominant firm reduces its output in response to the change in the CIT, this action may induce rival firms to increase their own output R. In that case industry output Y^I and therefore the price of output P_y would not change, preventing the dominant firm from shifting the CIT forward. However, in this context it is not relevant how likely or unlikely it is for a dominant firm to be able to succeed completely in shifting the CIT forward in the short run. We are merely interested in finding out what the firm's rental prices of capital services would be if it did succeed in shifting the tax completely. For the sake of the argument we therefore assume that entry conditions remain unchanged for the dominant or incumbent firm. Specifically, we assume that the difference between the firm's non-entry output and its actual output is the same before and after imposition of the CIT:

$$(24)\quad Y_t^{\&} - Y_t^{o} = Y_t^{+} - Y_t^{\#}(fs)$$

First-order condition (23) implicitly defines optimal output $Y_t^{\#}$ (fs) as

a function of the following variables:

$$(25)\quad Y_t^{\#}(fs) = Y_t^{\#}(fs)\,[X_t,\ P_{yst},\ W_{jt},\ K_{pt},\ I_{pt},\ K_{kt},\ I_{kt},\ t,\ T_{ct},\ k_4,\ k_5]$$

Replacing gross investment in the two capital stocks by the sum of replacement investment and net investment, and substituting equations (21) and (24) into Lagrangean (22), we obtain:

$$\begin{aligned}(26)\quad L = e_s \sum_{t=s}^{\infty} D_{s,t}\{ & (P_{yt})(Y_t^{o}) - G_t^{o}(\cdot) - (i_{t,t+a})(A_t) - (u_{pt})(K_{pt}^{\&}) \\ & - \delta_p(P_{pt})(K_{pt}) - (P_{pt+1})(K_{pt+1}) + (P_{pt})(K_{pt}) \\ & - \delta_k(P_{kt})(K_{kt}) - (P_{kt+1})(K_{kt+1}) + (P_{kt})(K_{kt}) + DA_{t+1} \\ & - k_2[DA_{t+1} - (P_{pt+1})(K_{pt+1}) + (P_{pt})(K_{pt}) - (P_{kt+1})(K_{kt+1}) + (P_{kt})(K_{kt})] \\ & - k_6[DR_{t+1} - c_t(Y_t^{+} - Y_t^{\#}(fs))]\}\end{aligned}$$

Lagrangean (26) does not contain any of the parameters of the CIT. It is therefore not surprising that under the assumptions made in this section the first-order conditions for the optimal stocks of physical and knowledge capital turn out to be free of tax parameters. The derivation of these optimality conditions can be found in appendix (4). They are given by:

$$(27)\quad \frac{-1}{1+r_{t,t+1}} e_t\{\frac{\partial g^{\#}_{t+1}}{\partial K^{\#}_{pt+1}}\} - \frac{\partial g^{\#}_t}{\partial I^{\#}_{pt}} + \frac{(1-\delta_p)}{1+r_{t,t+1}} e_t\{\frac{\partial g^{\#}_{t+1}}{\partial I^{\#}_{pt+1}}\} = \frac{1}{1+r_{t,t+1}} e_t\{p_{pt+1}\}[\delta_p + e_t\{i_{t+1,t+1+s}\}]$$

$$(28)\quad \frac{-1}{1+r_{t,t+1}} e_t\{\frac{\partial g^{\#}_{t+1}}{\partial K^{\#}_{kt+1}}\} - \frac{\partial g^{\#}_t}{\partial I^{\#}_{kt}} + \frac{(1-\delta_k)}{1+r_{t,t+1}} e_t\{\frac{\partial g^{\#}_{t+1}}{\partial I^{\#}_{kt+1}}\} = \frac{1}{1+r_{t,t+1}} e_t\{p_{kt+1}\}[\delta_k + e_t\{i_{t+1,t+1+s}\}]$$

The left-hand sides of these optimality conditions represent the expected net marginal benefits from increasing the two capital stocks, while their right-hand sides are the rental prices of the services from physical and knowledge capital respectively under the assumption that there is full short-run forward shifting of the CIT. In future these expressions for the rental prices of capital services will be referred to as $rp_{pt}(fs)$ [equation (27)] and as $rp_{kt}(fs)$ [equation (28)], where "fs" again denotes full shifting.

As mentioned before, for the Pakistani textile industry data limitations prevented us from incorporating R&D and the stock of knowledge capital into the model. For that industry the rental price of the services from knowledge capital [equation (28)] is therefore irrelevant.

First-order conditions (27) in the presence of full tax shifting and (15) in its absence, both correspond to equations (7) and (16) of Pindyck and Rotemberg (1983). The difference is that our optimality conditions are fully consistent with rational expectations on the part of firms, and that our model incorporates non-separable internal adjustment costs due to gross investment in physical and knowledge capital.

At the time of the imposition of (change in) the CIT the dominant firm's capital stocks are still the same as they would be in the absence of the tax. But over time the firm's optimal capital stocks $K^{\#}_p$ (fs) and $K^{\#}_k$ (fs) in the presence of full tax shifting evolve differently from its optimal capital stocks K_p^o and K_k^o prior to the change in the CIT. The reason for this difference is that the firm's equilibrium output Y_t^* (fs) in the case of full tax shifting is less than its optimal output Y_t^o prior to the change in the CIT, and a lower output results in lower equilibrium capital stocks as well.

Once again, the intent of this section of the paper was to derive expressions for the rental prices of capital services under the assumption that a firm with unexerted market power succeeds completely in passing the CIT on to consumers in the form of a higher output price. We do not claim that the case of full shifting is likely to occur often, it may never happen at all. All we are suggesting is that one should let the data decide whether or not full tax shifting occurred in a particular industry during the period being studied, rather than one's prior beliefs.

Appendix (6) discusses the functional form of the equations which were estimated. It also describes the non-nested hypothesis tests which were conducted to test the two pairs of rental prices for capital services, hence the two assumptions about the absence or presence of complete short-run tax shifting, against each other. The data are described in appendix (7), while the empirical results are presented in the next section.

4. Empirical results

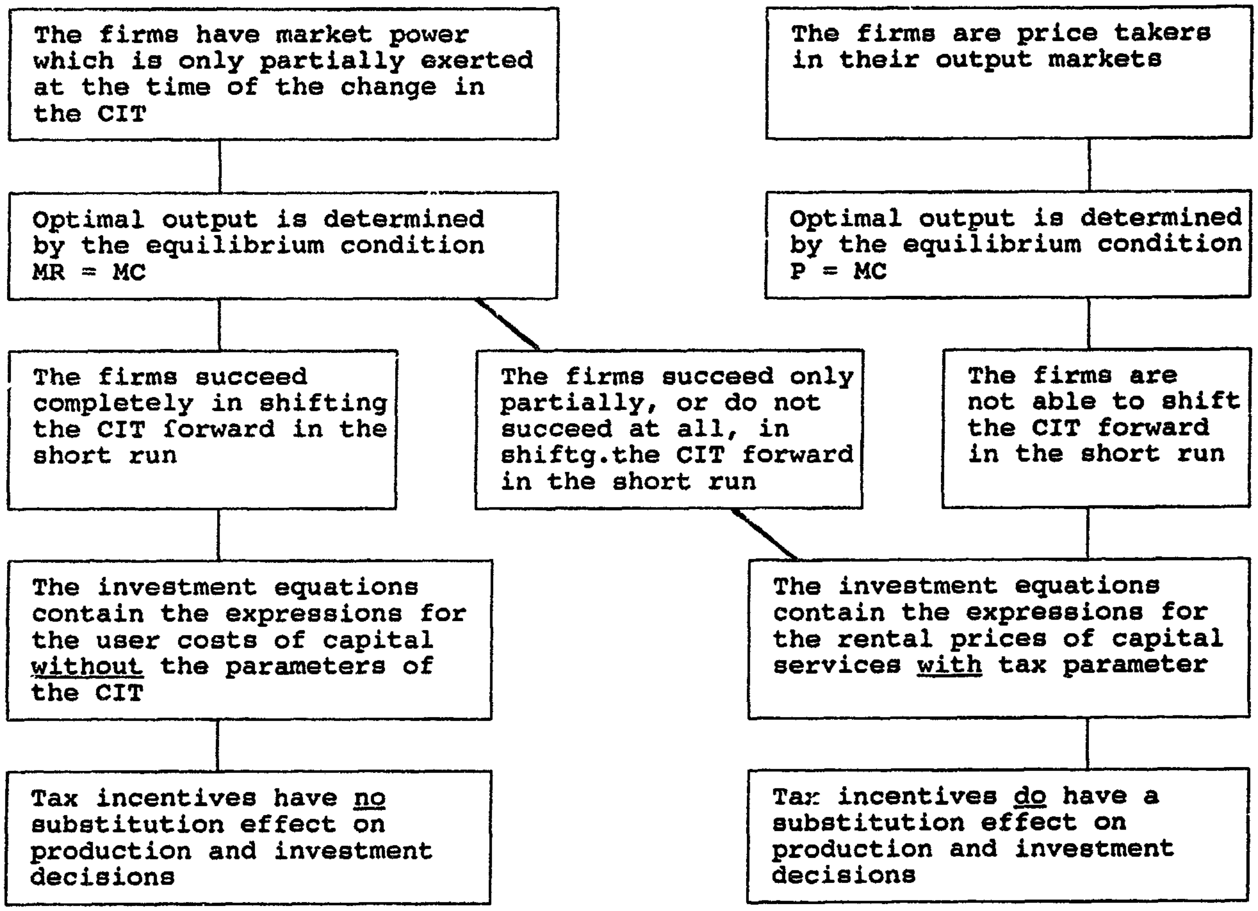
In section (3.2) above we made the assumption that there is perfect competition, i.e. that the firms are price takers in their output markets. Under the pair of assumptions that there is perfect competition and no short-run forward shifting of the CIT, our econometric models consists of equation (A35) for output, equations (A33) and (A34) for the variable inputs labour and materials, (A43) for investment in physical capital I_p, and (A44) for investment in knowledge capital I_k.

In section (3.3) above we explored what would happen if the firms in a given industry had unexerted market power and were able to shift the CIT on to consumers completely. For that pair of joint hypotheses our system of equations is given by (A36) for output Y, (A45) for I_p, and (A46) for I_k. Equations (A33) and (A34) for labour and materials are the same as for the alternative scenario of perfect competition and no shifting.

There is a third possibility, which we have not mentioned so far in order to keep the exposition clearer: the firms in a given industry may have market power, they may try to shift the CIT forward by raising the prices of their outputs, but they may be only partially successful in doing so; or they may not even try to shift the CIT forward if their market power is already fully exerted at the time of the change in the CIT. The pair of joint hypotheses "market power, partial or no tax shifting" represents the scenario which is perhaps the most likely one a priori. Under these joint hypotheses equations (A43) for output, (A33) and (A34) for the variable inputs labour and materials, (A43) for investment I_p in physical capital and (A44) for investment I_k in knowledge capital form the system of equations.

Due to data limitations the model for the Pakistani textile industry is a system of four rather than five equations, omitting the equation for investment in knowledge capital I_k. The three possible versions of the model are summarized in the chart below.

Summary chart for the different versions of the model



4.1 Pakistani textile industry

We tested the joint hypotheses "unexerted market power, partial or no tax shifting" and "perfect competition, no tax shifting" against each other by implementing a pair of non-nested hypothesis tests. Table (1) reports the results from these tests.

Table (1)
Pakistani textile industry
Results from the non-nested hypothesis tests

Specif.	H_0: perfect competition, partial or no tax shifting			H_0: unexerted market power, no tax shifting		
	$\hat{S}$	t		$\hat{S}$	t	
$W_1 = W_L$	0.974	18.53	H_0 rejected	0.0219	0.566	H_0 not rej.
$W_1 = W_M$	0.965	2.68	H_0 rejected	0.000181	0.896	H_0 not rej.

These results suggest quite strongly that the joint hypotheses of perfect competition and no tax shifting have to be rejected in favour of the hypotheses of market power and partial or no tax shifting. Making the conventional assumption of perfect competition for the textile industry of Pakistan would thus have involved a mis-specification of the econometric model, since the hypothesis of perfect competition was rejected quite decisively for this industry. However, even though our results indicate that the firms of the Pakistani textile industry had market power during the sample period instead of being perfectly competitive, the firms did not succeed completely in shifting the CIT forward in the short run. Therefore the parameters of the CIT entered the expression for the rental price of the services from physical capital, so that tax incentives had an effect on the user cost of capital of firms in this industry during the sample period.

To give an idea of the quality c. the estimation results, we report in table (2) below the elasticities of the demand for labour and for materials with respect to changes in the input prices for the mid-point of the sample. The results of table (2) show that both own-price elasticities have the correct negative sign. The formulae from which these elasticities were computed can be found in appendix (5).

Table (2)
Pakistani textile industry
Elasticities of the demand for labour and for materials with respect to the input prices, for 1974, unexerted market power and partial or no tax shifting
(estimated standard errors in brackets below the elasticities)

e_{LWL}	= − 0.194 (0.178)	e_{MWL}	= 0.541 (1.300)
e_{LWM}	= 0.182 (0.186)	e_{MWM}	= − 0.558 (1.343)
e_{LRPK}	= 0.0119 (0.0199)	e_{MRPK}	= 0.0165 (0.0717)

The non-nested hypothesis tests reported in table (1) above showed that the parameters of the CIT influenced the rental price of the services from physical capital for the Pakistani textile industry. It is therefore useful to determine what effect tax incentives had during the sample period on the decisions of this industry. Table (3) below reports the effect of a small change in the investment tax credit on the endogenous variables of the model during 1980, the mid-point of the time period within our sample during which the investment tax credit was in effect (1977 to 1983). The formulae from which these elasticities were calculated are given in appendix (5).

Table (3)
Pakistani textile industry
Elasticities of the endogenous variables of the model with respect to small changes in the investment tax credit, for 1980

e_{IMP} = 0.00251	e_{YMP} = − 0.00091
e_{LMP} = − 0.00136	e_{MMP} = − 0.01303

There are two channels through which changes in the rental price of the services from physical capital are transmitted to the demand for labour and for materials: A reduction in the rental price of capital services due to an increase in the tax credit increases investment expenditures, which in turn affect the demand for the variable inputs: If capital and labour (materials) are substitutes, the increase in investment expenditures reduces the demand for the variable inputs. If capital and labour (materials) are complements, the increase in investment expenditures increases the demand for the variable inputs. In addition, the increase in investment expenditures temporarily reduces output, hence the demand for the variable inputs labour and materials. The reason for this temporary reduction in output is that there are adjustment costs associated with investment expenditures, which manifest themselves as a short-run loss of output [see Treadway (1970) and (1974) on the desirability of this specification of adjustment costs as internal and non-separable].

Table 3 (b)
Impact of a 10% Increase in Investment Tax Credit on Textile Industry Investment and Government Revenues - in 1980.

Increase in Investment = Rupees 276,053

Reduction in Corporate Tax Revenues = Rupees 16,497,204

Incremental Benefit-Cost Ratio= Increase in Investment/Reduction in Corporate Tax Revenues = 0.017

Source : Model-based calculations

The results presented in Table 3 (b) suggest that an increase in the investment tax credit had the predicted but quite small effects on the endogenous variables of our model: It increased investment, and reduced output and the demand for labour and for materials. If the investment tax credit had been 10% larger in 1980, investment in the textile industry would have been approximately 276,000 Rupees higher during that year at a revenue loss of 16 million rupees. Thus the incremental benefit-cost ratio for investment tax credit was quite small.

4.2 Pakistani chemical and pharmaceutical industries

We first performed a pair of non-nested hypothesis tests to test the joint hypotheses "perfect competition, no tax shifting" and "market power, full tax shifting" against each other. The results are reported in table (4) below.

Table (4)
Pakistani chemical and pharmaceutical industries
Results from the first set of non-nested hypothesis tests

Specif.	H_0: market power, full shifting of the CIT			H_0: perfect competition, no shifting of the CIT		
	$\hat{S}$	t		$\hat{Q}$	t	
$W_1 = W_L$	1.004	20.01	H_0 rejected	0.198	0.583	H_0 not rej.
$W_1 = W_M$	0.555	1.56	H_0 not rej.	0.074	0.079	H_0 not rej.

As table (4) shows, the pair of joint hypotheses "perfect competition, no tax shifting" could not be rejected by the data and the competing pair of joint hypotheses for either specification of the model. On the other hand, the joint hypotheses "market power, full shifting" were rejected quite decisively for the specification with labour as the numéraire input.

It remained to be seen, however, whether the pair of hypotheses "perfect competition, no tax shifting" would do equally well against the pair of hypotheses "market power, partial or no tax shifting". To this end we tested these two pairs of joint hypotheses against each other in a second set of non-nested hypothesis tests, for which table (5) reports the results.

Table (5)
Pakistani chemical and pharmaceutical industries
Results from the second set of non-nested hypothesis tests

Specif.	H_0: market power, partial/no tax shifting			H_0: perfect competition, no shifting of the CIT		
	$\hat{S}$	t		$\hat{Q}$	t	
$W_1 = W_L$	0.218	1.60	H_0 not rej.	0.510	1.63	H_0 not rej.
$W_1 = W_M$	0.424	1.14	H_0 not rej.	1.065	11.78	H_0 rejected

The joint hypotheses "market power, partial or no tax shifting" could not be rejected by the competing pair of joint hypotheses for either specification of the model. On the other hand, "perfect competition, no tax shifting" was rejected quite decisively by the alternative pair of joint hypotheses for the specification with materials as the numéraire input.

Since our non-nested hypothesis tests show that full short-run forward shifting of the CIT has to be rejected for the industries we examined, we know that the CIT influenced the rental prices of capital services during the sample period. It is therefore useful to determine what effect tax incentives had on the decisions of the industries we studied. But first we report in table (6) below the elasticities of the demand for labour and for materials with respect to small changes in the wage rate, the price of materials, and the rental prices of investment in physical and knowledge capital. Then, in table (7), we show the effect of the investment tax credit for physical investment on the endogenous variables of the model. Finally, in table (8), we report the effect of a small reduction in the fraction of R&D which the firms are allowed to expense.

The formulae from which all these elasticities were computed can be found in appendix (5).

Table (6)
Pakistani chemical and pharmaceutical industries
Elasticities of the demand for labour and for materials
with respect to changes in the input prices, midpoint of the sample
(approximate standard errors in brackets)

e_{LWL} = − 0.761 (0.310)	e_{MWL} = 0.174 (0.190)
e_{LWM} = 0.781 (0.315)	e_{MWM} = − 0.188 (0.194)
e_{LRPK} = 0.00092 (0.00551)	e_{MRPK} = 0.0135 (0.0093)
e_{LRPP} = − 0.0202 (0.0140)	e_{MRPP} = 0.00008 (0.00016)

The results of table (6) show that the own-price elasticities both have the correct negative sign. Furthermore, the elasticities of the demand for labour with respect to small changes in the wage rate and in the price of materials are both statistically significant.

Table (7)
Pakistani chemical and pharmaceutical industries
Elasticities of R&D expenditures, physical investment, output, labour and materials with respect to small changes in the investment tax credit, midpoint of the sample

$$e_{IKMP} = -\ 0.108$$

$$e_{IPMP} = 0.386$$

$$e_{YMP} = -\ 0.026$$

$$e_{LMP} = -\ 0.0796$$

$$e_{MMP} = -\ 0.00015$$

Table (7) above reports the effect on the endogenous variables of the model of a small change in the tax credit for physical investment. An increase in the tax credit for physical investment reduces the rental price of the services from physical capital, which in turn results in more investment in physical capital, which is no doubt the effect intended by policy makers. The increase in investment causes adjustment costs in the form of a temporary reduction in output, which in turn lowers the demand for the variable inputs labour and materials.

Table 7(b)
Impact of a 10% Increase in Investment Tax Credit on Pakistani Chemical and Pharmaceutical Industries - in 1980.

Increase in Investment = Rupees (million) 20.530

Reduction in Corporate Tax Revenues = Rupees (million) 7.986

Increase in Investment / Reduction in Government Revenues = 2.6

Source : Model-based calculations

Table 7(b) reports on the impact of a small change in investment tax credit on government revenues and investment. It shows that for a 10% increase in investment tax credit, investment in physical capital would have increased by about 21 million rupees at a loss in government revenues of 8 million rupees yielding an incremental benefit-cost ratio of 2.6. Thus increases in investment tax credit would be a cost-effective policy instrument to promote private investment in Pakistani chemical and pharmaceutical industries.

Table (8) below reports the effect on the endogenous variables of a small reduction in the fraction of R&D which firms are allowed to treat as expenditures in the year in which they are incurred.

Table (8)
Pakistani chemical and pharmaceutical industries
Elasticities of R&D expenditures, physical investment, output, labour and materials with respect to a small reduction in the fraction of R&D which firms are allowed to expense, midpoint of the sample

$$e_{IKQK} = 0.657$$

$$e_{IPQK} = -0.597$$

$$e_{YQK} = -0.047$$

$$e_{LQK} = -0.00849$$

$$e_{MQK} = -0.0941$$

The effect of a small reduction below its present value of 1 in the proportion of R&D which the firms are allowed to expense, would be to increase rp_{kt}(tax) and to reduce investment in knowledge capital, i.e. expenditures on R&D. This is confirmed by the positive sign of e_{IKQK} which implies that R&D expenditures and the fraction q_k move in the same direction. If there were less R&D, output and therefore the demand for the variable inputs labour and materials would increase. It is interesting to note that for the industries of our sample an increase in R&D expenditures is not accompanied by an increase in physical investment. The reason may well be that in these industries R&D expenditures consist mainly of labour costs incurred in order to adapt innovations made elsewhere to the existing capital equipment.

Table 8 (b)
Impact of a 10% Reduction in R&D Tax Allowance on R&D Investments in Pakistani Chemical and Pharmaceutical Industries and Government Revenues

Reduction in R&D Expenditures = Rupees (million) 1.8
Increase in Government Revenues = Rupees (million) 1.0
Ratio of R&D Loss to Revenue Gains = 1.75

Source: Model-based calculations

Table 8(b) quantifies the impact of a 10% reduction in R&D tax allowance on R&D investment in Pakistani chemical and pharmaceutical industries. It shows that if the tax allowance for R&D had been 10% less, R&D expenditures would have been approximately 1.8 million Rupees lower and government revenues higher by a million rupees. Thus R&D tax allowance has fulfilled its policy objectives.

4.3 Turkish chemical and petroleum derivatives industries

Before presenting the results of our hypothesis tests, we report the elasticities of the demand for labour and for materials with respect to small changes in the wage rate, the price of materials, and the rental prices of investment in physical and knowledge capital in table (9).

Table (9)
Turkish chemical and petroleum derivatives industries
Elasticities of the demand for labour and for materials with respect to changes in the input prices, midpoint of the sample

(approximate standard errors in brackets)

e_{LWL}	= - 0.2975 (0.7297)	e_{MWL}	= 0.3593 (0.2979)
e_{LWM}	= 0.2970 (0.7286)	e_{MWM}	= - 0.3597 (0.2981)
e_{LRPK}	= 0.00028 (0.00039)	e_{MRPK}	= 0.00007 (0.00009)
e_{LRPP}	= 0.00019 (0.00116)	e_{MRPP}	= 0.00034 (0.00020)

The formulae from which these elasticities and those in all subsequent tables were computed can be found in appendix (5). In the above table WL stands for the price of labour, WM for the price of materials, RPK for the rental price of the services from knowledge capital, and RPP for the user cost of physical capital. These results show that the own-price elasticities both have the correct negative sign.

We first tested the pair of joint hypotheses "market power, full shifting of the CIT" and "perfect comptetition, no tax shifting" against each other. The results from these non-nested hypothesis tests were inconclusive, since neither pair of joint hypotheses was able to reject the alternative pair of hypotheses.

Next we tested the joint hypotheses "market power, full tax shifting" against the pair of hypotheses "market power, partial or no tax shifting". The results from this pair of non-nested hypothesis tests are reported in the next table.

Table (10)
Turkish chemical and petroleum derivatives industries
Results from the non-nested hypothesis tests

Specif.	H_0: market power, full shifting of the CIT			H_0: market power, partial or no shifting		
	$\hat{s}$	t		$\hat{s}$	t	
$W_1 = W_L$	1.007	3.702	H_0 rejected	0.212	0.735	H_0 not rej.
$W_1 = W_M$	0.492	0.987	H_0 not rej.	0.969	0.832	H_0 not rej.

The joint hypotheses "market power, partial or no tax shifting" could not be rejected by the competing pair of joint hypotheses for either specification of the model. On the other hand, the pair of hypotheses "market power, full tax shifting" was rejected by the alternative pair of joint hypotheses for the specification with labour as the numéraire input. This result agrees with what intuition predicts: While it is quite conceivable that the firms in the industries we studied had market power instead of being price takers, it is not very likely that they succeeded completely in passing the CIT on to their customers in the form of higher output prices.

Since our tests showed that full short-run forward shifting of the CIT has to be rejected for the industries of our sample, we know that the CIT influenced the rental prices of capital services during the sample period. Therefore it is useful to determine what effect tax incentives had on the production and investment decisions of the Turkish chemical and petroleum derivatives industries. In table (11), we report the effect of a small change in the tax allowance for investment in physical capital on the endogenous variables of the model. Table (12) reports the effect of a small change in the tax allowance for investment in knowledge capital, i.e. for R&D expenditures, on the endogenous variables of the model.

Table (11)
Turkish chemical and petroleum derivatives industries
Elasticities of R&D expenditures, physical investment, output, labour and materials with respect to small changes in the investment allowance for physical capital, midpoint of the sample

e_{IKQP}	=	0.00021
e_{IPQP}	=	0.00270
e_{YQP}	=	- 0.00148
e_{LQP}	=	- 0.00019
e_{MQP}	=	- 0.00052

An increase in the investment allowance for physical capital reduces the rental price of the services from physical capital, which in turn results in a small increase in investment in physical capital. Increased investment in physical capital is accompanied by more R&D expenditures. The increase in both types of investment causes adjustment costs in terms of temporarily reduced output, which in turn lowers the demand for the variable inputs labour and materials.

Table 11(b)
Impact of a 10% Increase in Investment Allowance on Investment in Turkish Chemical and Petroleum Derivatives Industries.

Increase in Investment = Turkish Lira 157,858
Lost tax Revenues = Turkish Lira 7,542,127
Ratio of Investment Gain to Revenue Loss = 0.02

Source: Model-based calculations

Table 11 (b) reports on the impact of a small increase in the investment allowance for physical capital on investment and government revenues. This table indicates that the investment allowances offered to Turkish industries had little impact on their investments but resulted in a major drain on government revenues.

Table (12) reports the effect on the endogenous variables of a small change in the tax allowance for investment in knowledge capital.

Table (12)
Turkish chemical and petroleum derivatives industries Elasticities of R&D expenditures, physical investment, output, labour and materials with respect to a small change in the fraction of R&D which firms are allowed to expense, midpoint of the sample

$$e_{IKQK} = 0.00336$$

$$e_{IPQK} = 0.01031$$

$$e_{YQK} = -0.00279$$

$$e_{LQK} = -0.00038$$

$$e_{MQK} = -0.00069$$

The positive sign of e_{IKQK} implies that a small change in the tax allowance for knowledge capital caused expenditures on R&D to move in the same direction. Investment in physical capital also moved in the same direction as R&D expenditures. This is what one would expect, since new technology is often embodied in new physical capital. Output and therefore the demand for the variable inputs labour and materials moved in the opposite direction in the short run only from changes in expenditures on R&D. This is what theory predicts, since investment is accompanied by short-run adjustment costs in terms of lost output.

Table 12 (b)
Impact of a 10% Reduction in R&D Allowance on R&D Investment By Turkish Chemical and Petroleum Derivatives Industries and Government Revenues

Reduction in R&D Investment = Turkish Lira 149,470

Gain in Tax Revenues = Turkish Lira 19,128,593

Ratio of R&D Investment Reduction to Gain in Tax Revenues = 0.008

Source: Model-based calculations

Table 12(b) suggests that R&D tax allowances for Turkish industries proved to be a poor instrument for stimulating R&D investment. Revenue losses to the treasury from this instrument far exceeded the investment gains.

5. Summary and policy implications

In this paper an intertemporal model of a firm optimizing its expected net present value was used to derive expressions for the rental prices of capital services which are consistent with rational expectations on the part of economic agents. Then it was demonstrated that if firms were successful in shifting the burden of the CIT completely on to consumers in the short run, the expressions for the rental prices of capital services would be free of the parameters of the CIT. The functional form of the variable cost function was specified, and the method of estimating the model was discussed. Non-nested hypothesis tests showed that for our samples the hypothesis of market power was able to reject that of perfect competition. However, even though the firms in the industries we studied had market power during the sample period, they were not able to shift the CIT forward completely in the short run. This result agrees with our prior expectation that while firms with unexerted market power are quite likely to make an attempt at passing the CIT on to their customers in the form of higher output prices, it is very unlikely that such attempts would be completely successful. Only in the case of complete short-run forward shifting of the CIT are the rental prices of capital services free of the parameters of the CIT. If the firms have to bear even part of the burden of the CIT in the short run, their after-tax profits differ from their profits prior to the tax change, and the parameters of the CIT do enter the expressions for the rental prices of capital services. Since for the firms in our samples tax incentives did have an effect on the production and investment decisions of the firms, we computed estimates of the effect of several tax incentives on the endogenous variables of the model.

If we had made the conventional assumption of perfect competition, we would have used equation (A35) for output, instead of equation (A36). As our non-nested hypothesis tests showed, for the industries we studied that would have been a mis-specification of the output equation, and any estimation results for such a mis-specified model would have been incorrect. Therefore we did not calculate any elasticities for the version of the model which assumes perfect competition, hence no shifting of the CIT.

With our non-nested hypothesis tests we were able to determine whether full short-run forward shifting of the CIT is absent or present. If full tax shifting is absent, our tests are not able to distinguish between different degrees of tax shifting. [The reason is that tax parameters affect the rental prices of capital services in situations of partial tax shifting as well as in the case of no shifting, and we test the user costs of capital with and without the tax parameters against each other.] This limitation of our model does not matter from the point of view of tax policy, however: Our non-nested hypothesis tests are able to answer the question whether tax incentives do or do not influence the rental prices of capital services. It is well known that the user cost of capital is one of the main channels through which tax incentives affect investment. Therefore it is important to test for the presence or absence of tax parameters in the rental prices of capital services, instead of assuming a priori that they are present.

Since the pre-condition for full tax shifting, i.e. unexerted market power, may well be met for some industries, but not for others, it is important to conduct these hypothesis tests for individual industries, rather than for the whole manufacturing sector. Collecting the required data and doing the necessary computations is a time consuming task, but one that is well worth the effort, given the important policy implications of the results.

Table 13 presents a summary of the results obtained in this paper on the effectiveness of tax incentives. The results are quite mixed and vary by industry. For example, in Pakistan investment tax credit had a highly stimulative impact on investment in chemical and pharmaceutical industries but little impact on the textile industry. R&D expensing also proved to be a cost-effective measure for the same industries. Turkish tax incentives measures (both an investment allowance and R&D expensing), on the other hand, resulted in higher revenue losses as compared to their investment impacts.

Table 13
A SUMMARY VIEW ON THE EFFECTIVENESS OF INVESTMENT INCENTIVES

Tax Instrument	Incremental benefit-cost ratio
Investment Tax Credit	
Pakistani Textile Industry	0.017
Pakistani Chemical & Pharmaceutical Industries	2.6
Investment Allowance	
Turkish Chemicals & Petroleum Derivatives Industries	0.02
R&D Expensing	
Pakistani Chemical & Pharmaceutical Industries	1.75
Turkish Chemical and Petroleum Derivatives Industries	0.008

Source: Model-based results

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Appendix (1): Derivation of Borrowing Constraint (4)

Equation (3) is repeated here for convenience as equation (A1):

$$(A1)\quad (P_{yt})(Y_t) - \sum_{j=1}^{2}(W_{jt})(v_{jt}) - (i_{t,t+a})(A_t) - (u_{pt})(K^{\&}_{pt}) - (P_{pt})(I_{pt}) -$$

$$(P_{kt})(I_{kt}) + DA_{t+1} - CITP_t \leq (P_{yt})(Y_t) - \sum_{j=1}^{2}(W_{jt})(v_{jt}) -$$

$$(i_{t,t+a})(A_t) - (u_{pt})(K^{\&}_{pt}) - \delta_p(P_{pt})(K_{pt}) - \delta_k(P_{kt})(K_{kt}) - CITP_t$$

Simplifying (A1):

$$(A2)\quad -(P_{pt})(I_{pt}) - (P_{kt})(I_{kt}) + DA_{t+1} \leq -\delta_p(P_{pt})(K_{pt}) - \delta_k(P_{kt})(K_{kt})$$

Gross investment in physical capital $(P_{pt})(I_{pt})$ is the sum of replacement investment $\delta_p(P_{pt})(K_{pt})$ and of net investment $(P_{pt+1})(K_{pt+1}) - (P_{pt})(K_{pt})$. Similarly, R&D expenditures $(P_{kt})(I_{kt})$ are the sum of replacement investment in knowledge capital $\delta_k(P_{kt})(K_{kt})$ and of net investment in knowledge capital $(P_{kt+1})(K_{kt+1}) - (P_{kt})(K_{kt})$. Therefore (A2) can be simplified further:

$$(A3)\quad -(P_{pt+1})(K_{pt+1}) + (P_{pt})(K_{pt}) - (P_{kt+1})(K_{kt+1}) + (P_{kt})(K_{kt}) + DA_{t+1} \leq 0$$

Since optimality requires this inequality to be strictly binding [see Boadway and Bruce (1979)], it can be re-written as the follwing equation:

$$(A4)\quad DA_{t+1} = (P_{pt+1})(K_{pt+1}) - (P_{pt})(K_{pt}) + (P_{kt+1})(K_{kt+1}) - (P_{kt})(K_{kt})$$

(A4) is the same as equation (4) in the text.

Appendix (2): Derivation of investment equation (5)

(A5) defines K_p^*, the value of the physical stock for tax purposes, at the beginning of period 1:

$$(A5) \quad (P_{p1})(K_{p1}^*) = [1-\alpha_{p0}](P_{p0})(K_{p0}^*) + (P_{p0})(I_{p0})$$

Similarly, the value of K_p^* at the beginning of periods 2, 3 and 4 is defined by equations (A6) to (A8):

$$(A6) \quad P_{p2}K_{p2}^* = (1-\alpha_{p1})(1-\alpha_{p0})P_{p0}K_{p0}^* + (1-\alpha_{p1})P_{p0}I_{p0} + P_{p1}I_{p1}$$

$$\begin{aligned}(A7) \quad P_{p3}K_{p3}^* = \; & (1-\alpha_{p2})(1-\alpha_{p1})(1-\alpha_{p0})P_{p0}K_{p0}^* + (1-\alpha_{p2})(1-\alpha_{p1})P_{p0}I_{p0} \\ & + (1-\alpha_{p2})P_{p1}I_{p1} + P_{p2}I_{p2}\end{aligned}$$

$$\begin{aligned}(A8) \quad P_{p4}K_{p4}^* = \; & (1-\alpha_{p3})(1-\alpha_{p2})(1-\alpha_{p1})(1-\alpha_{p0})P_{p0}K_{p0}^* + (1-\alpha_{p3})(1-\alpha_{p2})(1-\alpha_{p1})P_{p0}I_{p0} \\ & + (1-\alpha_{p3})(1-\alpha_{p2})P_{p1}I_{p1} + (1-\alpha_{p3})P_{p2}I_{p2} + P_{p3}I_{p3}\end{aligned}$$

$$\begin{aligned}(A9) \quad P_{p4}K_{p4}^* & - P_{p3}K_{p3}^* \\ & = [(1-\alpha_{p3})-1](1-\alpha_{p2})(1-\alpha_{p1})(1-\alpha_{p0})P_{p0}K_{p0}^* \\ & - (\alpha_{p3})(1-\alpha_{p2})(1-\alpha_{p1})P_{p0}I_{p0} - (\alpha_{p3})(1-\alpha_{p2})P_{p1}I_{p1} - (\alpha_{p3})P_{p2}I_{p2} \\ & + P_{p3}I_{p3} = (-\alpha_{p3})(P_{p3}K_{p3}^*) + P_{p3}I_{p3}\end{aligned}$$

By analogy:

$$(A10) \quad (P_{pt+1})(K_{pt+1}^*) - (P_{pt})(K_{pt}^*) = (-\alpha_{pt})[(P_{pt})(K_{pt}^*)] + (P_{pt})(I_{pt})$$

Solving (A10) for $(P_{pt})(I_{pt})$:

$$(A11) \quad (P_{pt})(I_{pt}) = (P_{pt+1})(K_{pt+1}^*) - (P_{pt})(K_{pt}^*) + (\alpha_{pt})(P_{pt})(K_{pt}^*)$$

(A11) is equal to (5) in the text. It is analogous to the following equation in terms of the stock of physical capital and its economic rate of depreciation:

$$(A12) \quad (P_{pt})(I_{pt}) = (P_{pt+1})(K_{pt+1}) - (P_{pt})(K_{pt}) + (\delta_p)(P_{pt})(K_{pt})$$

(A12) states the well-known fact that gross investment in physical capital is equal to net investment plus replacement investment.

Appendix (3): Derivation of equations (15) and (16)

For convenience equation (14) of section (3.2) is repeated here as (A13):

$$
\begin{aligned}
(A13)\quad L = \epsilon_s \sum_{t=s}^{\infty} D_{s,t}\{ & T_{ct}[(P_{yt})(Y_t^{\#}(\cdot)) - G_t^{\#}(\cdot) - (b_t)(i_{t,t+a})(A_t) - (u_{pt})(K_{pt}^{*}) \\
& - (1 - b_t)(i_{t,t+a})(A_t) + DA_{t+1} + (u_{ct})(\alpha_{kt})(P_{kt})(K_{kt}^{*}) \\
& + (u_{ct})(\alpha_{pt})(P_{pt})(K_{pt}^{*}) \\
& - [1 - (u_{ct})(q_{kt})][(\delta_k)(P_{kt})(K_{kt}) + (P_{kt+1})(K_{kt+1}) - (P_{kt})(K_{kt})] \\
& - [1-(u_{ct})(q_{pt})-(m_{pt})][(\delta_p)(P_{pt})(K_{pt})+(P_{pt+1})(K_{pt+1})-(P_{pt})(K_{pt})] \\
& - k_2[DA_{t+1} - (P_{pt+1})(K_{pt+1}) + (P_{pt})(K_{pt}) - (P_{kt+1})(K_{kt+1}) + (P_{kt})(K_{kt})] \\
& - k_1[\delta_p(P_{pt})(K_{pt}) + (P_{pt+1})(K_{pt+1}) - (P_{pt})(K_{pt}) - (\alpha_{pt})(P_{pt})(K_{pt}^{*}) \\
& - (P_{pt+1})(K_{pt+1}^{*}) + (P_{pt})(K_{pt}^{*})] \\
& - k_4[\delta_k(P_{kt})(K_{kt}) + (P_{kt+1})(K_{kt+1}) - (P_{kt})(K_{kt}) - (\alpha_{kt})(P_{kt})(K_{kt}^{*}) \\
& - (P_{kt+1})(K_{kt+1}^{*}) + (P_{kt})(K_{kt}^{*})]]\}
\end{aligned}
$$

Differentiating (A13) with respect to A_{t+1}, setting the derivative equal to zero, noting that at time t the variables of the same period are known with certainty, that $D_{t,t} = 1$ and that $D_{t,t+1} = 1/(1+i_{t,t+1})$:

$$
\begin{aligned}
(A14)\quad 0 = \; & [1 - k_2] + \epsilon_t\{[1/(1+i_{t,t+1})][-(T_{ct+1})(b_{t+1})(i_{t+1,t+1+a}) \\
& - (1 - b_{t+1})(i_{t+1,t+1+a}) - 1 + k_2]\}
\end{aligned}
$$

After combining terms and simplifying, (A14) can be re-written as:

$$
(A15)\quad -(k_2)(i_{t,t+1}) = -i_{t,t+1} + \epsilon_t\{i_{t+1,t+1+a}\}[1 - \epsilon_t\{b_{t+1}\}\epsilon_t\{u_{ct+1}\}]
$$

Implicit in (A15) and in subsequent equations is the assumption that the expected value of a product is equal to the product of the expected values.

Differentiating (A13) with respect to K_{pt+1}^{*} and setting the derivative equal to zero:

$$
\begin{aligned}
(A16)\quad 0 = \; & (k_1)\epsilon_t\{P_{pt+1}\} + \epsilon_t\{[1/(1+i_{t,t+1})][(\alpha_{pt+1})(u_{ct+1})(P_{pt+1}) \\
& + (k_1)(\alpha_{pt+1})(P_{pt+1}) - (k_1)(P_{pt+1})]\}
\end{aligned}
$$

Multiplying (A16) by $(1+i_{t,t+1})/\epsilon_t\{P_{pt+1}\}$ and solving for k_1:

$$(A17)\quad k_1 = \frac{-\,\epsilon_t\{\alpha_{pt+1}\}\,\epsilon_t\{u_{ct+1}\}}{i_{t,t+1} + \epsilon_t\{\alpha_{pt+1}\}} \quad .$$

Differentiating (A13) with respect to K_{pt+1}, setting the derivative equal to zero and noting that some terms vanish because of (12):

$$(A18)\quad 0 = -\; T_{ct}\frac{\partial G_t^{\#}}{\partial I_{pt}^{\#}}\;\underbrace{\frac{\partial I_{pt}^{\#}}{\partial K_{pt+1}^{\#}}}_{=1} + \epsilon_t\{P_{pt+1}\}[(m_{pt}) + (u_{ct})(q_{pt}) - 1 - k_1 + k_2]$$

$$+\; \epsilon_t\{D_{t,t+1}[(k_1)(1-\delta_p)(P_{pt+1}) - T_{ct+1}\frac{\partial G_{t+1}^{\#}}{\partial K_{pt+1}^{\#}} - T_{ct+1}\frac{\partial G_{t+1}^{\#}}{\partial I_{pt+1}^{\#}}\;\underbrace{\frac{\partial I_{pt+1}^{\#}}{\partial K_{pt+1}^{\#}}}_{=(\delta_p-1)}$$

$$-\; (1-\delta_p)(P_{pt+1})[(m_{pt+1}) + (u_{ct+1})(q_{pt+1}) - 1] - (k_2)(P_{pt+1})]\}$$

Re-arranging terms in (A18):

$$(A19)\quad -\frac{\epsilon_t\{T_{ct+1}\}}{1+i_{t,t+1}}\,\epsilon_t\{\frac{\partial G_{t+1}^{\#}}{\partial K_{pt+1}^{\#}}\} - T_{ct}\frac{\partial G_t^{\#}}{\partial I_{pt}^{\#}} + \frac{\epsilon_t\{T_{ct+1}\}}{1+i_{t,t+1}}\,\epsilon_t\{\frac{\partial G_{t+1}^{\#}}{\partial I_{pt+1}^{\#}}\}\,(1-\delta_p)$$

$$= \frac{\epsilon_t\{P_{pt+1}\}}{1+i_{t,t+1}}\,[(k_1) + (k_1)(i_{t,t+1}) - (k_1) + (k_1)(\delta_p)]$$

$$+ \frac{\epsilon_t\{P_{pt+1}\}}{1+i_{t,t+1}}[-(k_2) - (k_2)(i_{t,t+1}) + (k_2)]$$

$$- \frac{\epsilon_t\{P_{pt+1}\}}{1+i_{t,t+1}}(1-\delta_p)(1 - \epsilon_t\{m_{pt+1}\} - \epsilon_t\{u_{ct+1}\}\,\epsilon_t\{q_{pt+1}\})$$

$$+ \epsilon_t\{P_{pt+1}\}[1 - (m_{pt}) - (u_{ct})(q_{pt})]$$

Substituting (A15) and (A17) into (A19), and denoting the left-hand side of the equation by "LHS":

$$(A20)\quad LHS = \frac{\epsilon_t\{P_{pt+1}\}}{1+i_{t,t+1}}(\delta_p - 1) + \epsilon_t\{P_{pt+1}\}$$
$$- \epsilon_t\{P_{pt+1}\}[(u_{ct})(q_{pt}) - \frac{(1-\delta_p)\epsilon_t\{u_{ct+1}\}\epsilon_t\{q_{pt+1}\}}{1+i_{t,t+1}}]$$
$$- \epsilon_t\{P_{pt+1}\}[(m_{pt}) - \frac{(1-\delta_p)\epsilon_t\{m_{pt+1}\}}{1+i_{t,t+1}}]$$
$$- \frac{(i_{t,t+1})\epsilon_t\{P_{pt+1}\}}{1+i_{t,t+1}} + \frac{\epsilon_t\{P_{pt+1}\}}{1+i_{t,t+1}}[\epsilon_t\{i_{t+1,t+1+s}\}(1 - \epsilon_t\{b_{t+1}\}\epsilon_t\{u_{ct+1}\})]$$
$$- \frac{\epsilon_t\{P_{pt+1}\}(i_{t,t+1} + \delta_p)\epsilon_t\{\alpha_{pt+1}\}\epsilon_t\{u_{ct+1}\}}{(1+i_{t,t+1})(i_{t,t+1} + \epsilon_t\{\alpha_{pt+1}\})}$$

Combining terms in (A20):

$$(A21)\quad LHS = \frac{\epsilon_t\{P_{pt+1}\}}{1+i_{t,t+1}}[\delta_p + \epsilon_t\{i_{t+1,t+1+s}\}(1 - \epsilon_t\{b_{t+1}\}\epsilon_t\{u_{ct+1}\})]$$
$$- \epsilon_t\{P_{pt+1}\}[(m_{pt}) - \frac{(1-\delta_p)\epsilon_t\{m_{pt+1}\}}{1+i_{t,t+1}}]$$
$$- \epsilon_t\{P_{pt+1}\}[(u_{ct})(q_{pt}) - \frac{(1-\delta_p)\epsilon_t\{u_{ct+1}\}\epsilon_t\{q_{pt+1}\}}{1+i_{t,t+1}}]$$
$$- \frac{\epsilon_t\{P_{pt+1}\}(i_{t,t+1} + \delta_p)\epsilon_t\{\alpha_{pt+1}\}\epsilon_t\{u_{ct+1}\}}{(1+i_{t,t+1})(i_{t,t+1} + \epsilon_t\{\alpha_{pt+1}\})}$$

Replacing the nominal variables of (A21) by their real counterparts:

$$G_{t+1} = (1 + \pi_{0,t})(1 + \pi_{t,t+1})g_{t+1}$$

$$G_t = (1 + \pi_{0,t})g_t$$

$$P_{pt+1} = (1 + \pi_{0,t})(1 + \pi_{t,t+1})p_{pt+1}$$

$$(1+i_{t,t+1}) = (1 + r_{t,t+1})(1 + \pi_{t,t+1})$$

$$
\begin{aligned}
(A22)\quad & -\frac{(1+\pi_{0,t})(1+\pi_{t,t+1})\epsilon_t\{T_{ct+1}\}}{(1+r_{t,t+1})(1+\pi_{t,t+1})}\epsilon_t\{\frac{\partial g^{\#}_{t+1}}{\partial K^{\#}_{pt+1}}\} - (1+\pi_{0,t})T_{ct}\frac{\partial g^{\#}_t}{\partial I^{\#}_{pt}} \\
& + \frac{(1+\pi_{0,t})(1+\pi_{t,t+1})\epsilon_t\{T_{ct+1}\}}{(1+r_{t,t+1})(1+\pi_{t,t+1})}\epsilon_t\{\frac{\partial g^{\#}_{t+1}}{\partial I^{\#}_{pt+1}}\}(1-\delta_p) \\
& = \frac{(1+\pi_{0,t})(1+\pi_{t,t+1})\epsilon_t\{p_{pt+1}\}}{(1+r_{t,t+1})(1+\pi_{t,t+1})}[\delta_p + \epsilon_t\{i_{t+1,t+1+s}\}(1-\epsilon_t\{b_{t+1}\}\epsilon_t\{u_{ct+1}\})] \\
& - \epsilon_t\{p_{pt+1}\}[(1+\pi_{0,t})(1+\pi_{t,t+1})(u_{ct})(q_{pt}) \\
& - \frac{(1-\delta_p)(1+\pi_{0,t})(1+\pi_{t,t+1})\epsilon_t\{u_{ct+1}\}\epsilon_t\{q_{pt+1}\}}{(1+r_{t,t+1})(1+\pi_{t,t+1})}] \\
& - \epsilon_t\{p_{pt+1}\}[(1+\pi_{0,t})(1+\pi_{t,t+1})(m_{pt}) - \frac{(1-\delta_p)(1+\pi_{0,t})(1+\pi_{t,t+1})\epsilon_t\{m_{pt+1}\}}{(1+r_{t,t+1})(1+\pi_{t,t+1})}] \\
& - \frac{(1+\pi_{0,t})(1+\pi_{t,t+1})\epsilon_t\{p_{pt+1}\}(i_{t,t+1}+\delta_p)\epsilon_t\{\alpha_{pt+1}\}\epsilon_t\{u_{ct+1}\}}{(1+r_{t,t+1})(1+\pi_{t,t+1})(i_{t,t+1}+\epsilon_t\{\alpha_{pt+1}\})}
\end{aligned}
$$

Dividing both sides of (A22) by $(1+\pi_{0,t})\epsilon_t\{T_{ct+1}\}$:

$$
\begin{aligned}
(A23)\quad & -\frac{1}{1+r_{t,t+1}}\epsilon_t\{\frac{\partial g^{\#}_{t+1}}{\partial K^{\#}_{pt+1}}\} - \frac{T_{ct}}{\epsilon_t\{T_{ct+1}\}}\frac{\partial g^{\#}_t}{\partial I^{\#}_{pt}} + \frac{(1-\delta_p)}{1+r_{t,t+1}}\epsilon_t\{\frac{\partial g^{\#}_{t+1}}{\partial I^{\#}_{pt+1}}\} \\
& = \frac{1}{1+r_{t,t+1}}\frac{\epsilon_t\{p_{pt+1}\}}{\epsilon_t\{T_{ct+1}\}}[\epsilon_t\{i_{t+1,t+1+s}\}(1-\epsilon_t\{b_{t+1}\}\epsilon_t\{u_{ct+1}\}) + \delta_p] \\
& - (1+\pi_{t,t+1})\frac{\epsilon_t\{p_{pt+1}\}}{\epsilon_t\{T_{ct+1}\}}(u_{ct})(q_{pt}) + \frac{(1-\delta_p)}{(1+r_{t,t+1})}\frac{\epsilon_t\{p_{pt+1}\}}{\epsilon_t\{T_{ct+1}\}}\epsilon_t\{u_{ct+1}\}\epsilon_t\{q_{pt+1}\} \\
& - (1+\pi_{t,t+1})\frac{\epsilon_t\{p_{pt+1}\}}{\epsilon_t\{T_{ct+1}\}}(m_{pt}) + \frac{(1-\delta_p)\epsilon_t\{p_{pt+1}\}}{(1+r_{t,t+1})\epsilon_t\{T_{ct+1}\}}\epsilon_t\{m_{pt+1}\} \\
& - \frac{\epsilon_t\{p_{pt+1}\}(i_{t,t+1}+\delta_p)\epsilon_t\{\alpha_{pt+1}\}\epsilon_t\{u_{ct+1}\}}{\epsilon_t\{T_{ct+1}\}(1+r_{t,t+1})(i_{t,t+1}+\epsilon_t\{\alpha_{pt+1}\})}
\end{aligned}
$$

Equation (A23) is equal to equation (15) in the text. Equation (16) of the text is analogous to (15), except that the subscript "p" for physical capital has to be replaced by the subscript "k" for knowledge capital, and m_{kt} as well as $\epsilon_t\{m_{kt+1}\}$ are equal to zero, since in both countries there is a tax allowance rather than a tax credit for R&D expenditures. The interested reader can verify this by differentiating (A13) with respect to A_{t+1}, K_{kt+1} and K^{*}_{kt+1}, and eliminating the Lagrangean multipliers k_1 and k_2 by substitution, as was done above.

Appendix (4): Derivation of Equations (27) and (28)

For convenience the Lagrangean of equation (26) of the text is repeated here as (A24):

$$
\begin{aligned}
(A24)\quad L = e_s \sum_{t=s}^{\infty} D_{s,t}\{ & (P_{yt})(Y_t^o) - G_t^o(.) - (i_{t,t+a})(A_t) - (u_{pt})(K_{pt}^t) \\
& - \delta_p(P_{pt})(K_{pt}) - (P_{pt+1})(K_{pt+1}) + (P_{pt})(K_{pt}) \\
& - \delta_k(P_{kt})(K_{kt}) - (P_{kt+1})(K_{kt+1}) + (P_{kt})(K_{kt}) + DA_{t+1} \\
& - k_2[DA_{t+1} - (P_{pt+1})(K_{pt+1} + (P_{pt})(K_{pt}) - (P_{kt+1})(K_{kt+1}) + (P_{kt})(K_{kt})] \\
& - k_6[DR_{t+1} - c_t(Y_t^* - Y_t^s(fs))]\}
\end{aligned}
$$

Differentiating (A24) with respect to A_{t+1}, setting the derivative equal to zero, noting that current period variables are known with certainty, and that $D_{t,t+1} = 1/(1+i_{t,t+1}$, we obtain:

$$(A25)\quad 0 = 1 - k_2 + \frac{1}{1+i_{t,t+1}}[k_2 - 1 - e_t\{i_{t+1,t+1+a}\}]$$

Multiplying both sides of (A25) by $(1+i_{t,t+1})$ and simplifying:

$$(A26)\quad (i_{t,t+1})(1 - k_2) = e_t\{i_{t+1,t+1+a}\}$$

Differentiating (A24) with respect to K_{pt+1}, setting the derivative equal to zero, and noting that several terms vanish because of first-order condition (23) in the text:

$$(A27)\quad 0 = -\frac{\partial G_t^o}{\partial I_{pt}^o}\underbrace{\frac{\partial I_{pt}^o}{\partial K_{pt+1}^o}}_{=1} - \epsilon_t\{P_{pt+1}\}[1-k_2]$$

$$+\frac{1}{1+i_{t,t+1}}\left[-\epsilon_t\{\frac{\partial G_{t+1}^o}{\partial K_{pt+1}^o}\} + \epsilon_t\{P_{pt+1}\}(1-\delta_p-k_2) - \epsilon_t\{\frac{\partial G_{t+1}^o}{\partial I_{pt+1}^o}\underbrace{\frac{\partial I_{pt+1}^o}{\partial K_{pt+1}^o}}_{=(\delta_p-1)}\}\right]$$

Re-arranging terms in (A27):

$$(A28)\quad -\frac{1}{1+i_{t,t+1}}\epsilon_t\{\frac{\partial G_{t+1}^o}{\partial K_{pt+1}^o}\} - \frac{\partial G_t^o}{\partial I_{pt}^o} + \frac{(1-\delta_p)}{1+i_{t,t+1}}\epsilon_t\{\frac{\partial G_{t+1}^o}{\partial I_{pt+1}^o}\}$$
$$= \frac{\epsilon_t\{P_{pt+1}\}}{1+i_{t,t+1}}[(i_{t,t+1})(1-k_2)+\delta_p]$$

Substituting (A26) into (A28):

$$(A29)\quad LHS = \frac{\epsilon_t\{P_{pt+1}\}}{1+i_{t,t+1}}[\delta_p + \epsilon_t\{i_{t+1,t+1+s}\}]$$

In order to obtain real rather than nominal variables, (A29) can be re-written as follows:

$$(A30)\quad -\frac{(1+\pi_{0,t})(1+\pi_{t,t+1})}{(1+r_{t,t+1})(1+\pi_{t,t+1})}\epsilon_t\{\frac{\partial g_{t+1}^o}{\partial K_{pt+1}^o}\} - (1+\pi_{0,t})\frac{\partial g_t^o}{\partial I_{pt}^o}$$
$$+\frac{(1+\pi_{0,t})(1+\pi_{t,t+1})}{(1+r_{t,t+1})(1+\pi_{t,t+1})}\epsilon_t\{\frac{\partial g_{t+1}^o}{\partial I_{pt+1}^o}\}(1-\delta_p)$$
$$= \frac{(1+\pi_{0,t})(1+\pi_{t,t+1})}{(1+r_{t,t+1})(1+\pi_{t,t+1})}\epsilon_t\{p_{pt+1}\}[\delta_p + \epsilon_t\{i_{t+1,t+1+s}\}]$$

Dividing both sides of (A30) by $(1+\pi_{0,t})$:

$$(A31)\quad -\frac{1}{1+r_{t,t+1}}\epsilon_t\{\frac{\partial g_{t+1}^o}{\partial K_{pt+1}^o}\} - \frac{\partial g_t^o}{\partial I_{pt}^o} + \frac{(1-\delta_p)}{1+r_{t,t+1}}\epsilon_t\{\frac{\partial g_{t+1}^o}{\partial I_{pt+1}^o}\}$$
$$= \frac{\epsilon_t\{p_{pt+1}\}}{1+r_{t,t+1}}[\delta_p + \epsilon_t\{i_{t+1,t+1+s}\}]$$

(A31) is equal to equation (27) of the text. Furthermore, if in (A23) we set $q_{pt} = \epsilon_t\{q_{pt+1}\} = \epsilon_t\{u_{ct+1}\} = 0$, therefore $T_{ct} = \epsilon_t\{T_{ct+1}\} = 1$, then (A23) reduces to (A31).

Equation (28) of the text can be derived in an analogous way: (A24) is differentiated with respect to K_{kt+1}, and the derivative is set equal to zero. After substituting for k_2 from (A26), one obtains optimality condition (28) of the text.

Appendix (5): Formulae for price-elasticities of factor demands, and for the elasticities of the endogenous variables with respect to changes in the tax allowances for investment in physical and knowledge capital, and with respect to changes in the tax credit for investment in physical capital, v_1 used as the numéraire input, assuming partial or no forward shifting of the CIT.

We define:

$$DENP = [a_{PP} + (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIP} - a_{PIP}(1-\delta_p)]$$

$$DENK = [a_{KK} + (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IKIK} - a_{KIK}(1-\delta_p)]$$

$$\begin{aligned}
e_{11} = \{ & a_{22}(w_{2t}) - [a_Y + a_{YY}(Y_t) + a_{PY}(K_{pt}) + a_{KY}(K_{kt}) + a_{YT}(t) + a_{IPY}(I_{pt}) + a_{IKY}(I_{kt})](F_2) \\
& + [a_{IP} + a_{IPIP}(I_{pt}) + a_{PIP}(K_{pt}) + a_{KIP}(K_{kt}) + a_{IPIK}(I_{kt}) + a_{IPY}(Y_t) + a_{IPT}(t)] \\
& \quad (1+r_{t,t+1})(T_{ct}/\epsilon_t\{T_{ct+1}\})\, a_{IP2}/DENP \\
& + [a_{IK} + a_{PIK}(K_{pt}) + a_{IKIK}(I_{kt}) + a_{KIK}(K_{kt}) + a_{IPIK}(I_{pt}) + a_{IKY}(Y_t) + a_{IKT}(t)] \\
& \quad (1+r_{t,t+1})(T_{ct}/\epsilon_t\{T_{ct+1}\})\, a_{IK2}/DENK\}(w_{2t}/v_{1t}) \\
& + \{[a_{IK} + a_{IKIK}(I_{kt}) + a_{PIK}(K_{pt}) + a_{KIK}(K_{kt}) + a_{IPIK}(I_{pt}) + a_{IKY}(Y_t) + a_{IKT}(t)] \\
& \quad (1+r_{t,t+1})[rp_{kt}(tax)]/DENK\}(1/v_{1t}) \\
& + \{[a_Y + a_{YY}(Y_t) + a_{PY}(K_{pt}) + a_{KY}(K_{kt}) + a_{YT}(t) + a_{IPY}(I_{pt}) + a_{IKY}(I_{kt})](F_{IK}) \\
& \quad (1+r_{t,t+1})[rp_{kt}(tax)]/DENK\}(1/v_{1t}) \\
& + \{[a_{IP} + a_{IPIP}(I_{pt}) + a_{PIP}(K_{pt}) + a_{KIP}(K_{kt}) + a_{IPIK}(I_{kt}) + a_{IPY}(Y_t) + a_{IPT}(t)] \\
& \quad (1+r_{t,t+1})[rp_{pt}(tax)]/DENP\}(1/v_{1t}) \\
& + \{[a_Y + a_{YY}(Y_t) + a_{PY}(K_{pt}) + a_{KY}(K_{kt}) + a_{YT}(t) + a_{IPY}(I_{pt}) + a_{IKY}(I_{kt})](F_{IP}) \\
& \quad (1+r_{t,t+1})[rp_{pt}(tax)]/DENP\}(1/v_{1t}) = -[e_{12} + e_{1P} + e_{1K}]
\end{aligned}$$

$$e_{12} = \{ - (a_{22})(W_{2t}) + [a_Y + a_{YY}(Y_t) + a_{PY}(K_{pt}) + a_{KY}(K_{kt}) + a_{YT}(t) + a_{IPY}(I_{pt}) + a_{IKY}(I_{kt})](F_2)$$
$$- [a_{IP} + a_{IPIP}(I_{pt}) + a_{PIP}(K_{pt}) + a_{KIP}(K_{kt}) + a_{IPIK}(I_{kt}) + a_{IPY}(Y_t) + a_{IPT}(t)]$$
$$(1+r_{t,t+1})(T_{ct}/\epsilon_t\{T_{ct+1}\})\, a_{IP2}/DENP$$
$$- [a_{IK} + a_{PIK}(K_{pt}) + a_{IKIK}(I_{kt}) + a_{KIK}(K_{kt}) + a_{IPIK}(I_{pt}) + a_{IKY}(Y_t) + a_{IKT}(t)]$$
$$(1+r_{t,t+1})(T_{ct}/\epsilon_t\{T_{ct+1}\})\, a_{IK2}/DENK\}(w_{2t}/v_{1t})$$

$$e_{1K} = \{ - [a_{IK} + a_{IKIK}(I_{kt}) + a_{PIK}(K_{pt}) + a_{KIK}(K_{kt}) + a_{IPIK}(I_{pt}) + a_{IKY}(Y_t) + a_{IKT}(t)]$$
$$(1+r_{t,t+1})[rp_{kt}(tax)]/DENK\}(1/v_{1t})$$
$$- \{[a_Y + a_{YY}(Y_t) + a_{PY}(K_{pt}) + a_{KY}(K_{kt}) + a_{YT}(t) + a_{IPY}(I_{pt}) + a_{IKY}(I_{kt})](F_{IK})$$
$$(1+r_{t,t+1})[rp_{kt}(tax)]/DENK\}(1/v_{1t})$$

$$e_{1P} = \{ - [a_{IP} + a_{IPIP}(I_{pt}) + a_{PIP}(K_{pt}) + a_{KIP}(K_{kt}) + a_{IPIK}(I_{kt}) + a_{IPY}(Y_t) + a_{IPT}(t)]$$
$$(1+r_{t,t+1})[rp_{pt}(tax)]/DENP\}(1/v_{1t})$$
$$- \{[a_Y + a_{YY}(Y_t) + a_{PY}(K_{pt}) + a_{KY}(K_{kt}) + a_{YT}(t) + a_{IPY}(I_{pt}) + a_{IKY}(I_{kt})](F_{IP})$$
$$(1+r_{t,t+1})[rp_{pt}(tax)]/DENP\}(1/v_{1t})$$

$$e_{21} = \{ - a_{22} - (a_{Y2})(F_2) + (a_{IP2})^2(T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})/DENP$$
$$+ (a_{IK2})^2(T_{ct}/\epsilon_t\{(T_{ct+1})(1+r_{t,t+1})/DENK\}(w_{2t}/v_{2t})$$
$$+ \{[a_{IK2} + (a_{Y2})(F_{IK})](1+r_{t,t+1})/DENK\}[rp_{kt}(tax)/v_{2t}]$$
$$+ \{[a_{IP2} + (a_{Y2}(F_{IP})](1+r_{t,t+1})/DENP\}[rp_{pt}(tax)/v_{2t}] = - [e_{22} + e_{2P} + e_{2K}]$$

$$e_{22} = \{a_{22} + (a_{Y2})(F_2) - (a_{IP2})^2(T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})/DENP$$
$$- (a_{IK2})^2(T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})/DENK\}(w_{2t}/v_{2t})$$

$$e_{2K} = - \{[a_{IK2} + (a_{Y2})(F_{IK})]\ (1+r_{t,t+1})/DENK\}[rp_{Kt}(tax)/v_{2t}]$$

$$e_{2P} = - \{[a_{IP2} + (a_{Y2})(F_{IP})]\ (1+r_{t,t+1})/DENP\}[rp_{pt}(tax)/v_{2t}]$$

If the assumption of full short-run forward shifting of the CIT cannot be rejected by the data and the competing model, the following modifications have to be made in the above formulae: $T_{ct} = \epsilon_t\{T_{ct+1}\} = 1$, and $rp_{pt}(tax)$ and $rp_{kt}(tax)$ have to be replaced by $rp_{pt}(fs)$ and $rp_{kt}(fs)$.

For the Pakistani textile industry $I_{kt} = K_{kt} = rp_{kt}(tax) = rp_{kt}(fs) = 0$, since we were not able to include R&D and knowledge capital into the model for that industry because of data limitations.

<u>The effect of a change in the tax allowance for investment in knowledge capital on the endogenous variables (not relevant for the Pakistani textile industry)</u>:

$$\begin{aligned} e_{1QK} = \{ & [a_{IK} + a_{PIK}(K_{pt}) + a_{IKIK}(I_{kt}) + a_{KIK}(K_{kt}) + a_{IPIK}(I_{pt}) + a_{IKY}(Y_t) + a_{IKT}(t)] \\ & + [a_Y + a_{YY}(Y_t) + a_{PY}(K_{pt}) + a_{KY}(K_{kt}) + a_{YT}(t) + a_{IPY}(I_{pt}) + a_{IKY}(I_{kt})](F_{IK}) \\ & + [a_{IP} + a_{IPIP}(I_{pt}) + a_{PIP}(K_{pt}) + a_{KIP}(K_{kt}) + a_{IPIK}(I_{kt}) + a_{IPY}(Y_t) + a_{IPT}(t)] \\ & [a_{KIP}(1-\delta_p) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK}]/DENP_t\} \\ & [(1+r_{t,t+1})(1+\pi_{t,t+1})\epsilon_t\{p_{kt+1}\}(u_{ct})(q_{kt})]/[(DENK_t)(\epsilon_t\{T_{ct+1}\})(v_{1t})] \end{aligned}$$

$$\begin{aligned} e_{2QK} = \{ & a_{IK2} + (a_{Y2})(F_{IK}) + (a_{IP2}[a_{KIP}(1-\delta_p) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK}]/DENP_t\} \\ & [(1+i_{t,t+1})\epsilon_t\{p_{kt+1}\}(u_{ct})(q_{kt})]/[(DENK_t)(\epsilon_t\{T_{ct+1}\})(v_{2t})] \end{aligned}$$

$$e_{IKQK} = [(1+i_{t,t+1})\epsilon_t\{p_{kt+1}\}(u_{ct})(q_{kt})]/[(DENK_t)(\epsilon_t\{T_{ct+1}\})(I_{kt})]$$

$$\begin{aligned} e_{IPQK} = & [a_{KIP}(1-\delta_p) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK} \\ & - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})(a_{IPY})(F_{IK})] \\ & [(1+i_{t,t+1})\epsilon_t\{p_{kt+1}\}(u_{ct})(q_{kt})]/[(DENP_t)(DENK_t)(\epsilon_t\{T_{ct+1}\})(I_{pt})] \end{aligned}$$

$$\begin{aligned} e_{YQK} = \{ & F_{IK} + (F_{IP})[a_{KIP}(1-\delta_p) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK}]/DENP_t\} \\ & [(1+i_{t,t+1})\epsilon_t\{p_{kt+1}\}(u_{ct})(q_{kt})]/[(DENK_t)(\epsilon_t\{T_{ct+1}\})(Y_t)] \end{aligned}$$

<u>The effect of a change in the tax allowance for investment in physical capital on the endogenous variables (relevant only for Turkey)</u>:

$$\begin{aligned} e_{1QP} = \{ & [a_{IP} + a_{IPIP}(I_{pt}) + a_{PIP}(K_{pt}) + a_{KIP}(K_{kt}) + a_{IPIK}(I_{kt}) + a_{IPY}(Y_t) + a_{IPT}(t)] \\ & + [a_Y + a_{YY}(Y_t) + a_{PY}(K_{pt}) + a_{KY}(K_{kt}) + a_{IPY}(I_{pt}) + a_{IKY}(I_{kt}) + a_{YT}(t)](F_{IP}) \\ & + [a_{IK} + a_{PIK}(K_{pt}) + a_{IKIK}(I_{kt}) + a_{KIK}(K_{kt}) + a_{IPIK}(I_{pt}) + a_{IKY}(Y_t) + a_{IKT}(t)] \\ & [a_{PIK}(1-\delta_k) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK}]/DENK_t\} \\ & [(1+i_{t,t+1})\epsilon_t\{p_{pt+1}\}(u_{ct})(q_{pt})]/[(DENP_t)(\epsilon_t\{T_{ct+1}\})(v_{1t})] \end{aligned}$$

$$e_{2QP} = \{a_{IP2} + (a_{Y2})(F_{IP}) + (a_{IK2}[a_{PIK}(1-\delta_k) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK}]/DENK_t\}$$
$$[(1+i_{t,t+1})\epsilon_t\{p_{pt+1}\}(u_{ct})(q_{pt})]/[(DENP_t)(\epsilon_t\{T_{ct+1}\})(v_{2t})]$$

$$e_{IKQP} = [a_{PIK}(1-\delta_k) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK}$$
$$- (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})(a_{IKY})(F_{IP})]$$
$$[(1+i_{t,t+1})\epsilon_t\{p_{pt+1}\}(u_{ct})(q_{pt})]/[(DENK_t)(DENP_t)(\epsilon_t\{T_{ct+1}\})(I_{kt})]$$

$$e_{IPQP} = [(1+i_{t,t+1})\epsilon_t\{p_{pt+1}\}(u_{ct})(q_{pt})]/[(DENP_t)(\epsilon_t\{T_{ct+1}\})(I_{pt})]$$

$$e_{YQP} = \{F_{IP} + (F_{IK})[a_{PIK}(1-\delta_k) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK}]/DENK_t\}$$
$$[(1+i_{t,t+1})\epsilon_t\{p_{pt+1}\}(u_{ct})(q_{pt})]/[(DENP_t)(\epsilon_t\{T_{ct+1}\})(Y_t)]$$

<u>The effect of a change in the tax credit for investment in physical capital on the endogenous variables (relevant only for Pakistan):</u>

$$e_{1MP} = \{[a_{IP}+a_{IPIP}(I_{pt})+a_{PIP}(K_{pt})+a_{KIP}(K_{kt})+a_{IPIK}(I_{kt})+a_{IPY}(Y_t)+a_{IPT}(t)]$$
$$+ [a_Y+a_{YY}(Y_t)+a_{PY}(K_{pt})+a_{KY}(K_{kt})+a_{IPY}(I_{pt})+a_{IKY}(I_{kt})+a_{YT}(t)](F_{IP})$$
$$+ [a_{IK}+a_{PIK}(K_{pt})+a_{IKIK}(I_{kt})+a_{KIK}(K_{kt})+a_{IPIK}(I_{pt})+a_{IKY}(Y_t)+a_{IKT}(t)]$$
$$[a_{PIK}(1-\delta_k) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK}]/DENK_t\}$$
$$[(1+i_{t,t+1})\epsilon_t\{p_{pt+1}\}(m_{pt})]/[(DENP_t)(\epsilon_t\{T_{ct+1}\})(v_{1t})]$$

$$e_{2MP} = \{a_{IP2} + (a_{Y2})(F_{IP})$$
$$+ (a_{IK2})[a_{PIK}(1-\delta_k) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK}]/DENK_t\}$$
$$[(1+i_{t,t+1})\epsilon_t\{p_{pt+1}\}(m_{pt})]/[(DENP_t)(\epsilon_t\{T_{ct+1}\})(v_{2t})]$$

$$e_{IKMP} = [a_{PIK}(1-\delta_k) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK}$$
$$- (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})(a_{IKY})(F_{IP})]$$
$$[(1+i_{t,t+1})\epsilon_t\{p_{pt+1}\}(m_{pt})]/[(DENK_t)(DENP_t)(\epsilon_t\{T_{ct+1}\})(I_{kt})]$$

$$e_{IPMP} = [(1+i_{t,t+1})\epsilon_t\{p_{pt+1}\}(m_{pt})]/[(DENP_t)(\epsilon_t\{T_{ct+1}\})(I_{pt})]$$

$$e_{YMP} = \{F_{IP} + (F_{IK})\,[a_{PIK}(1-\delta_k) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})\,(1+r_{t,t+1})\,a_{IPIK}]\,/DENK_t\}$$
$$[(1+i_{t,t+1})\,\epsilon_t\{p_{pt+1}\}(m_{pt})]\,/\,[(DENP_t)\,(\epsilon_t\{T_{ct+1}\})\,(Y_t)]$$

As previously mentioned, for the textile industry the model did not include R&D expenditures or knowledge capital. Therefore e_{IKMP} does not apply for that industry, and $DENK_t$ as well as all the terms involving I_{kt} and K_{kt} are equal to zero in the remaining formulae above.

If the assumption of complete short-run forward shifting of the CIT could not be rejected by the data and the competing hypothesis of partial or no tax shifting, the following conditions would hold:

$e_{1QK} = e_{2QK} = e_{IKQK} = e_{IPQK} = e_{YQK} = 0,$

$e_{1QP} = e_{2QP} = e_{IKQP} = e_{IPQP} = e_{YQP} = 0,$ and

$e_{1MP} = e_{2MP} = e_{IKMP} = e_{IPMP} = e_{YMP} = 0.$

In other words, neither the tax allowance for investment in physical capital, nor the tax allowance for R&D expenditures, nor the tax credit for investment in physical capital, would have any effect on the endogenous variables of the model. The reason for this is that under the assumption of full tax shifting the allowance for R&D expenditures does not occur in $rp_{kt}(fs)$, the rental price of the services from knowledge capital [see equation (28) in the text]. Neither do the tax allowance and the tax credit for physical investment occur in the expression for $rp_{pt}(fs)$, the rental price of the services from physical capital [see equation (27) of the text].

Appendix (6): Specification of functional form, method of estimation, and non-nested hypothesis tests

Following the example of Pindyck and Rotemberg (1983), the optimality conditions derived in sections (3.2) and (3.3) above can be used as alternative estimating equations for investment I_{pt} and I_{kt}. The estimating equations for the variable inputs can be obtained from Shephard's Lemma [see R.W. Shephard (1953) and (1970)].

The variable cost function g_t is approximated by a quadratic normalized variable cost function, which provides a second-order approximation to an arbitrary normalized variable cost function. Using a quadratic specification has the advantage that the first-order conditions can be solved explicitly for the optimal rates of investment. Using the quadratic functional form has the disadvantage, however, that the quadratic is not invariant to the choice of numéraire input. Therefore the model has to be estimated twice, using labour and materials as the numéraire input in turn.

The quadratic normalized variable cost function with the input price W_{1t} as the numéraire is specified as follows:

$$
\begin{aligned}
\text{(A32)}\quad G_t/W_{1t} &= v_{1t} + (w_{2t})v_{2t} = g_t[w_{2t}, K_{pt}, K_{kt}, I_{pt}, I_{kt}, Y_t, t] \\
&= a_0 + a_2(w_{2t}) + a_p(K_{pt}) + a_K(K_{kt}) + a_{IP}(I_{pt}) + a_{IK}(I_{kt}) + a_Y(Y_t) \\
&+ a_t(t) + 0.5\,[a_{pp}(K_{pt})^2 + a_{KK}(K_{kt})^2 + a_{IPIP}(I_{pt})^2 + a_{IKIK}(I_{kt})^2 \\
&+ a_{YY}(Y_t)^2 + a_{tt}(t)^2 + a_{22}(w_{2t})^2] + a_{P2}(K_{pt})(w_{2t}) + a_{PK}(K_{pt})(K_{kt}) \\
&+ a_{PIP}(K_{pt})(I_{pt}) + a_{PIK}(K_{pt})(I_{kt}) + a_{PY}(K_{pt})(Y_t) + a_{Pt}(K_{pt})(t) \\
&+ a_{K2}(K_{kt})(w_{2t}) + a_{KIP}(K_{kt})(I_{pt}) + a_{KIK}(K_{kt})(I_{kt}) + a_{KY}(K_{kt})(Y_t) \\
&+ a_{Kt}(K_{kt})(t) + a_{IP2}(I_{pt})(w_{2t}) + a_{IPIK}(I_{pt})(I_{kt}) + a_{IPY}(I_{pt})(Y_t) \\
&+ a_{IPt}(I_{pt})(t) + a_{IK2}(I_{kt})(w_{2t}) + a_{IKY}(I_{kt})(Y_t) + a_{IKt}(I_{kt})(t) \\
&+ a_{Y2}(Y)(w_{2t}) + a_{Yt}(Y)(t) + a_{t2}(t)(w_{2t}),
\end{aligned}
$$

where $w_{2t} = W_{2t}/W_{1t}$, and the a's are coefficients to be estimated.

The demand for input v_{2t} is given by Shephard's Lemma as $\partial g_t/\partial w_{2t}$. An additive disturbance term allows for errors in optimization and/or measurement and for omitted variables:

$$\text{(A33)}\quad v_{2t} = a_2 + a_{22}(w_{2t}) + a_{P2}(K_{pt}) + a_{K2}(K_{kt}) + a_{IP2}(I_{pt}) + a_{IK2}(I_{kt}) + a_{Y2}(Y_t) + a_{t2}(t) + u_{2t}$$

The demand for input v_{1t} can be obtained from the normalized variable cost function as follows:

$$\begin{aligned}\text{(A34)}\quad v_{1t} &= (G_t/W_{1t}) - (w_{2t})(v_{2t}) \\ &= a_0 + a_p(K_{pt}) + a_K(K_{kt}) + a_{IP}(I_{pt}) + a_{IK}(I_{kt}) + a_Y(Y_t) + a_t(t) \\ &+ 0.5[a_{pp}(K_{pt})^2 + a_{KK}(K_{kt})^2 + a_{IPIP}(I_{pt})^2 + a_{IKIK}(I_{kt})^2 + a_{YY}(Y_t)^2 \\ &+ a_{tt}(t)^2 - a_{22}(w_{2t})^2] + a_{PK}(K_{pt})(K_{kt}) + a_{PIP}(K_{pt})(I_{pt}) \\ &+ a_{PIK}(K_{pt})(I_{kt}) + a_{PY}(K_{pt})(Y_t) + a_{Pt}(K_{pt})(t) + a_{KIP}(K_{kt})(I_{pt}) \\ &+ a_{KIK}(K_{kt})(I_{kt}) + a_{KY}(K_{kt})(Y_t) + a_{Kt}(K_{kt})(t) + a_{IPIK}(I_{pt})(I_{kt}) \\ &+ a_{IPY}(I_{pt})(Y_t) + a_{IPt}(I_{pt})(t) + a_{IKY}(I_{kt})(Y_t) + a_{IKt}(I_{kt})(t) \\ &+ a_{Yt}(Y_t)(t) + u_{1t}\end{aligned}$$

Under the assumption of perfect competition the estimating equation for output is a linear approximation of equation (13). Only the observable variables are used as explanatory variables, and the F's are coefficients to be estimated:

$$\text{(A35)}\quad Y_t = F_0 + F_{PY}(P_{yt}/W_{1t}) + F_2(w_{2t}) + F_p(K_{pt}) + F_K(K_{kt}) + F_{IP}(I_{pt}) + F_{IK}(I_{kt}) + F_t(t) + u_{yt}$$

Under the assumption that the dominant firm (group of firms) has market power and reduces its output in response to a change in the CIT, the estimating equation for output is a linear approximation of equation (25), again with only the observable variables used as explanatory variables:

$$\text{(A36)}\quad Y_t = F_0 + F_X(X_t/W_{1t}) + F_{PYS}(P_{yst}/W_{1t}) + F_2(w_{2t}) + F_p(K_{pt}) + F_K(K_{kt}) + F_{IP}(I_{pt}) + F_{IK}(I_{kt}) + F_c(T_{ct}) + F_t(t) + u_{yt}$$

Estimating equations for gross investment I_{pt} and I_{kt} can be obtained from equilibrium conditions (15) and (16) or (27) and (28), according to which the expected net marginal benefits from physical and knowledge capital have to be equal to the rental price of capital services. K_{pt} and K_{kt}, the capital stocks at the beginning of period t, are given to the firm, but the next period's capital stocks are determined by optimality conditions (15), (16) or (27), (28). Therefore I_{pt} [$= \delta_p K_{pt} + (K_{pt+1} - K_{pt})$] and I_{kt} [$= \delta_k K_{kt} + (K_{kt+1} - K_{kt})$] are endogenous variables. In order to solve (15), (16) or (27), (28) for the optimal rates of investment, the following derivatives are required:

$$\text{(A37)}\quad \partial g_{t+1}/\partial K_{pt+1} = a_p + a_{pp}(K_{pt+1}) + a_{pK}(K_{kt+1}) + a_{p2}(w_{2t+1}) + a_{pY}(Y_{t+1}) + a_{PIP}(I_{pt+1}) + a_{PIK}(I_{kt+1}) + a_{Pt}(t+1)$$

$$\text{(A38)}\quad \partial g_t/\partial I_{pt} = a_{IP} + a_{IPIP}(I_{pt}) + a_{IPIK}(I_{kt}) + a_{IP2}(w_{2t}) + a_{PIP}(K_{pt}) + a_{KIP}(K_{kt}) + a_{IPY}(Y_t) + a_{IPt}(t)$$

$$\text{(A39)}\quad \partial g_{t+1}/\partial I_{pt+1} = a_{IP} + a_{IPIP}(I_{pt+1}) + a_{IPIK}(I_{kt+1}) + a_{IP2}(w_{2t+1}) + a_{PIP}(K_{pt+1}) + a_{KIP}(K_{kt+1}) + a_{IPY}(Y_{t+1}) + a_{IPt}(t+1)$$

$$\text{(A40)}\quad \partial g_{t+1}/\partial K_{kt+1} = a_K + a_{KK}(K_{kt+1}) + a_{pK}(K_{pt+1}) + a_{K2}(w_{2t+1}) + a_{KY}(Y_{t+1}) + a_{KIP}(I_{pt+1}) + a_{KIK}(I_{kt+1}) + a_{Kt}(t+1)$$

$$\text{(A41)}\quad \partial g_t/\partial I_{kt} = a_{IK} + a_{IKIK}(I_{kt}) + a_{IPIK}(I_{pt}) + a_{IK2}(w_{2t}) + a_{PIK}(K_{pt}) + a_{KIK}(K_{kt}) + a_{IKY}(Y_t) + a_{IKt}(t)$$

$$\text{(A42)}\quad \partial g_{t+1}/\partial I_{kt+1} = a_{IK} + a_{IKIK}(I_{kt+1}) + a_{IPIK}(I_{pt+1}) + a_{IK2}(w_{2t+1}) + a_{PIK}(K_{pt+1}) + a_{KIK}(K_{kt+1}) + a_{IKY}(Y_{t+1}) + a_{IKt}(t+1)$$

Under the assumption that there is partial or no short-run forward shifting of the CIT we substitute (A37) to (A39) into optimality condition (15), replace K_{pt+1} by $(I_{pt} + K_{pt} - \delta_p K_{pt})$ and K_{kt+1} by $(I_{kt} + K_{kt} - \delta_k K_{kt})$, solve for gross investment in physical capital I_{pt}, and add an error term:

$$
\begin{aligned}
(A43)\quad I_{pt} = \; & [1/(a_{PP} + (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIP} - a_{PIP}(1-\delta_p))] \\
& \{(1-\delta_p)a_{IP} - a_P - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IP} \\
- \; & (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IP2}(w_{2t}) + [(1-\delta_p)a_{IP2} - a_{P2}]\,\epsilon_t\{w_{2t+1}\} \\
+ \; & [a_{PIP}(1-\delta_p)^2 - a_{PP}(1-\delta_p) - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{PIP}](K_{pt}) \\
+ \; & [a_{KIP}(1-\delta_p)(1-\delta_k) - a_{PK}(1-\delta_k)\;(T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{KIP}](K_{kt}) \\
+ \; & [a_{KIP}(1-\delta_p) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK}](I_{kt}) \\
- \; & (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPY}(Y_t) + [(1-\delta_p)a_{IPY} - a_{PY}]\,\epsilon_t\{Y_{t+1}\} \\
- \; & (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPt}(t) + [(1-\delta_p)a_{IPt} - a_{Pt}](t+1) \\
+ \; & [(1-\delta_p)a_{IPIP} - a_{PIP}]\,\epsilon_t\{I_{pt+1}\} + [(1-\delta_p)a_{IPIK} - a_{PIK}]\,\epsilon_t\{I_{kt+1}\} \\
- \; & (1+r_{t,t+1})\,rp_{pt}(tax)\} + u_{Ipt}
\end{aligned}
$$

Equation (A43) shows that investment in physical capital I_{pt} depends not only on the stock of physical capital K_{pt} and on next period's expected investment $\epsilon_t\{I_{pt+1}\}$, but also on the stock of knowledge capital K_{kt}, on R&D expenditures for the current period, and on $\epsilon_t\{I_{kt+1}\}$, the amount of R&D expected for the next period.

Similarly, under the same assumption of partial or no short-run forward shifting we substitute (A40) to (A42) into optimality condition (16), again substituting $[I_{pt} + K_{pt} - \delta_p K_{pt}]$ for K_{pt+1} and $[I_{kt} + K_{kt} - \delta_k K_{kt}]$ for K_{kt+1}. This time we solve for R&D expenditures I_{kt}, and again add an error term:

$$
\begin{aligned}
(A44)\quad I_{kt} = \; & [1/(a_{KK} + (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IKIK} - a_{KIK}(1-\delta_k))] \\
& \{(1-\delta_k)a_{IK} - a_K - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IK} \\
- \; & (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IK2}(w_{2t}) + [(1-\delta_k)a_{IK2} - a_{K2}]\,\epsilon_t\{w_{2t+1}\} \\
+ \; & [a_{KIK}(1-\delta_k)^2 - a_{KK}(1-\delta_k) - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{KIK}](K_{kt}) \\
+ \; & [a_{PIK}(1-\delta_k)(1-\delta_p) - a_{PK}(1-\delta_p) - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{PIK}](K_{pt}) \\
+ \; & [a_{PIK}(1-\delta_k) - a_{PK} - (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IPIK}](I_{pt}) \\
- \; & (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IKY}(Y_t) + [(1-\delta_k)a_{IKY} - a_{KY}]\,\epsilon_t\{Y_{t+1}\} \\
- \; & (T_{ct}/\epsilon_t\{T_{ct+1}\})(1+r_{t,t+1})a_{IKt}(t) + [(1-\delta_k)a_{IKt} - a_{Kt}](t+1) \\
+ \; & [(1-\delta_k)a_{IKIK} - a_{KIK}]\,\epsilon_t\{I_{kt+1}\} + [(1-\delta_k)a_{IPIK} - a_{KIP}]\,\epsilon_t\{I_{pt+1}\} \\
- \; & (1+r_{t,t+1})\,rp_{kt}(tax)\} + u_{Ikt}
\end{aligned}
$$

Equation (A44) shows that R&D expenditures I_{kt} depend not only on the stock of knowledge capital K_{kt} and on next period's expected R&D expenditures

$\epsilon_t\{I_{kt+1}\}$, but also on the stock of physical capital K_{pt}, on current gross investment in physical capital I_{pt}, and on $\epsilon_t\{I_{pt+1}\}$, the amount of investment in physical capital expected for the next period. Due to a limited sample size we were not able to include equation (A44) in the system of equations for the Pakistani textile industry.

Next we show what the two estimating equations for investment in physical and knowledge capital would be in an industry with unexerted market power, if the firms succeeded in shifting the CIT forward completely. To this end we substitute (A37) to (A39) into first-order condition (27), and (A40) to (A42) into optimality condition (28). First-order conditions (27) and (28) differ from conditions (15) and (16) only in two respects: The factor $(T_{ct}/\epsilon_t\{T_{ct+1}\}$ is missing from the second term on the left-hand side of (27) and (28), and the right-hand sides of (27) and (28) represent the rental prices of capital services under the assumption of full shifting, while the right-hand sides of (15) and (16) represent the rental prices of capital services in the absence of full short-run shifting of the CIT. Therefore the following alternative estimating equations for investment in physical capital I_{pt} and for R&D expenditures I_{kt} can also be obtained from (A43) and (A44) by setting $T_{ct} = \epsilon_t\{T_{ct+1}\} = 1$, and by replacing $rp_{pt}(tax)$ with $rp_{pt}(fs)$ and $rp_{kt}(tax)$ with $rp_{kt}(fs)$:

$$
\begin{aligned}
(A45)\quad I_{pt} = \; & [1/(a_{pp} + (1+r_{t,t+1})a_{IPIP} - a_{PIP}(1-\delta_p))]\{ - a_p - (\delta_p + r_{t,t+1})a_{IP} \\
& - (1+r_{t,t+1})a_{IP2}(W_{2t}) + [(1-\delta_p)a_{IP2} - a_{P2}]\epsilon_t\{W_{2t+1}\} \\
& + [a_{PIP}(1-\delta_p)^2 - a_{PP}(1-\delta_p) - (1+r_{t,t+1})a_{PIP}](K_{pt}) \\
& + [a_{KIP}(1-\delta_p)(1-\delta_k) - a_{PK}(1-\delta_k) - (1+r_{t,t+1})a_{KIP}](K_{kt}) \\
& + [a_{KIP}(1-\delta_p) - a_{PK} - (1+r_{t,t+1})a_{IPIK}](I_{kt}) \\
& - (1+r_{t,t+1})a_{IPY}(Y_t) + [(1-\delta_p)a_{IPY} - a_{PY}]\epsilon_t\{Y_{t+1}\} \\
& - (1+r_{t,t+1})a_{IPt}(t) + [(1-\delta_p)a_{IPt} - a_{Pt}](t+1) \\
& + [(1-\delta_p)a_{IPIP} - a_{PIP}]\epsilon_t\{I_{pt+1}\} + [(1-\delta_p)a_{IPIK} - a_{PIK}]\epsilon_t\{I_{kt+1}\} \\
& - (1+r_{t,t+1})rp_{pt}(fs)\} + u_{Ipt}
\end{aligned}
$$

$$
\begin{aligned}
\text{(A46)}\quad I_{kt} = {} & [1/(a_{KK} + (1+r_{t,t+1})a_{IKIK} - a_{KIK}(1-\delta_k))]\{ - a_K - (\delta_k + r_{t,t+1})a_{IK} \\
& - (1+r_{t,t+1})a_{IK2}(w_{2t}) + [(1-\delta_k)a_{IK2} - a_{K2}]\,\epsilon_t\{w_{2t+1}\} \\
& + [a_{KIK}(1-\delta_k)^2 - a_{KK}(1-\delta_k) - (1+r_{t,t+1})a_{KIK}](K_{kt}) \\
& + [a_{PIK}(1-\delta_k)(1-\delta_p) - a_{PK}(1-\delta_p) - (1+r_{t,t+1})a_{PIK}](K_{pt}) \\
& + [a_{PIK}(1-\delta_k) - a_{PK} - (1+r_{t,t+1})a_{IPIK}](I_{pt}) \\
& - (1+r_{t,t+1})a_{IKY}(Y_t) + [(1-\delta_k)a_{IKY} - a_{KY}]\,\epsilon_t\{Y_{t+1}\} \\
& - (1+r_{t,t+1})a_{IKt}(t) + [(1-\delta_k)a_{IKt} - a_{Kt}](t+1) \\
& + [(1-\delta_k)a_{IKIK} - a_{KIK}]\,\epsilon_t\{I_{kt+1}\} + [(1-\delta_k)a_{IPIK} - a_{KIP}]\,\epsilon_t\{I_{pt+1}\} \\
& - (1+r_{t,t+1})rp_{kt}(fs)\} + u_{Ikt}
\end{aligned}
$$

[Due to data limitations (A46) was omitted from the system of equations we estimated for the Pakistani textile industry.]

(A33) to (A35), (A43) and (A44) form the system of five simultaneous equations which is estimated under the assumption of perfect competition, hence no short-run forward shifting of the CIT. For the competing assumption of market power and full tax shifting the relevant system of equations consists of (A33), (A34), (A36), (A45) and (A46). Since the endogenous variables output and investment occur as explanatory variables in the other equations, the systems have to be estimated with non-linear three-stage least squares [3SLS] in order to avoid simultaneous equations bias. The following exogenous variables are used as the instruments under the assumption that there is no full tax shifting: K_{pt}, K_{kt}, t, (P_{yt}/W_{1t}) [P_{yt} = nominal price of output], w_{2t} [= W_{2t}/W_{1t} = real price of variable input 2], $\epsilon_t\{w_{2t+1}\}$, rp_{pt}(tax), and rp_{kt}(tax). Under the assumption that the CIT is fully shifted forward in the short run, the exogenous variables K_{pt}, K_{kt}, t, (X_t/W_{1t}) [X_t = current dollar GNP or GDP], (P_{yst}/W_{1t}) [P_{yst} = nominal price of substitute products], w_{2t}, $\epsilon_t\{w_{2t+1}\}$, T_{ct} [= 1 - u_{ct}, where u_{ct} is the statutory rate of the CIT], $\epsilon_t\{T_{ct+1}\}$, rp_{pt}(fs) and rp_{kt}(fs) are used as the instruments. Both systems have to be estimated twice, using labour and materials as the numéraire input in turn.

The question arises how to obtain the expected values of future exogenous and endogenous variables. It would be possible to obtain the expected values of the exogenous variables w_{2t+1}, T_{ct+1}, b_{t+1}, p_{pt+1} and p_{kt+1}, given the information set Ω_t, by determining the variables which Granger-cause these exogenous variables. Granger causality is defined as follows: "We say that Y_t is causing X_t if we are better able to predict X_t using all available information than if the information apart from Y_t had been used." [Granger (1969:428)]. Having obtained the Granger-causing variables, one could then assume that they form the information set Ω_t. The choice of Granger-causing variables is bound to be somewhat arbitrary, however, so that different researchers would not use the same variables. The method used by Kennan (1979) does not suffer from this drawback. His argument can be summarized as follows: Under the assumption of rational expectations, economic agents use all the relevant information available to them at time t, in order to make unbiased forecasts of the future values of certain stochastic variables. Therefore the subsequent realizations of these stochastic variables can be used as "backcasts" of the unobservable expectations, and expected values can be replaced by their subsequently realized actual values [J. Kennan (1979), at pp. 1444, 1447, 1453].

After replacing the expected values of the exogenous variables by their subsequent realizations, there are still the expected values of the endogenous variables to be dealt with in the estimating equations for investment in physical capital [I_{pt}] and in knowledge capital [R&D expenditures I_{kt}]: the expected values of Y_{t+1}, I_{pt+1} and I_{kt+1}, given Ω_t. These endogenous variables can be handled by using the definition of rational expectations due to Muth: "Expectations, since they are informed predictions of future events, are essentially the same as the predictions of the relevant economic theory." [J.F.

Muth (1961:316)] The relevant economic theory for obtaining the endogenous variables would be the three estimating equations for output, physical investment and R&D expenditures, all of them shifted forward by one time period. But since $\epsilon_t\{Y_{t+1}\}$ occurs as an explanatory variable in the equations for investment, and $\epsilon_t\{I_{pt+1}\}$ and $\epsilon_t\{I_{kt+1}\}$ occur in the equation for next period's output, all of them have to be replaced by instruments to avoid simultaneous equations bias. Regressing Y_{t+1}, I_{pt+1} and I_{kt+1} on the exogenous variables of the next time period provides the instruments for $\epsilon_t\{Y_{t+1}\}$, $\epsilon_t\{I_{pt+1}\}$ and $\epsilon_t\{I_{kt+1}\}$. The instruments are those listed above for the two competing assumptions about the absence or presence of complete tax shifting, except that they are all moved forward by one time period.

In order to outline the non-nested hypothesis tests [see J.G. MacKinnon (1983)] whose results are reported in section (4) of the text, it is useful to re-write the two systems of equations more compactly. Under the twin assumptions of unexerted market power and full short-run forward shifting of the CIT the system of equations can be written as follows:

$$\text{(A47)}\quad [I_{pt}, I_{kt}, L_t, M_t, Y_t]' = f_{jt}(\beta, xp_{pt}(fs), xp_{kt}(fs), p_{yst}, x_t) + u_{jt}^{fs}, \qquad u_{jt}^{fs} \sim N(0, \Omega_{fs}),$$

where β is the vector of regression coefficients obtained by estimating the system (A47), and in this context Ω stands for the variance-covariance matrix of the system of five equations. Because of data limitations we estimated a system of only four equations for the Pakistani textile industry. Therefore the equation for R&D expenditures I_{kt} has to be omitted from (A47) above, and from (A48) to (A50) below.

Assuming perfect competition and the absence of complete short-run forward shifting, the system of equations can be written as:

$$(A48)\quad [I_{pt}, I_{kt}, L_t, M_t, Y_t]' = F_{jt}(\tau, rp_{pt}(tax), rp_{kt}(tax), p_{yt}) + u_{jt}^{tax}, \quad u_{jt}^{tax} \sim N(0, \Omega_{tax}),$$

where τ is the vector of regression coefficients obtained by estimating (A48).

Testing the null-hypothesis that complete short-run forward shifting of the CIT is present against the alternative hypothesis that full shifting is absent involves estimating the following composite model:

$$(A49)\quad [I_{pt}, I_{kt}, L_t, M_t, Y_t]' = (1-S)\,[f_{jt}(\beta, rp_{pt}(fs), rp_{kt}(fs), p_{yst}, x_t)] + (S)\,(\hat{F}_{jt}) + u_{jt}^{c}, \quad u_{jt}^{c} \sim N(O, \Omega_{fs})$$

where $\hat{F}_{jt} = F_{jt}(\hat{\tau}, rp_{pt}(tax), rp_{kt}(tax), p_{yt})$ are the fitted values of the dependent variables obtained by estimating the system of equations (A48). The test statistic is the value of t for the estimate of the coefficient S.

Testing the null-hypothesis that complete tax shifting is absent against the alternative hypothesis that it is present involves estimating the following composite model:

$$(A50)\quad [I_{pt}, I_{kt}, L_t, M_t, Y_t]' = (1-Q)\,[F_{jt}(\tau, rp_{pt}(tax), rp_{kt}(tax), p_{yt})] + (Q)\,(\hat{f}_{jt}) + u_{jt}^{c'}, \quad u_{jt}^{c'} \sim N(0, \Omega_{Tax})$$

where $\hat{f}_{jt} = f_{jt}(\hat{\beta}, rp_{pt}(fs), rp_{kt}(fs), p_{yst}, x_t)$ are the fitted values of the dependent variables from estimating the system of equations (A47). The test statistic is the value of t for the estimate of the coefficient Q.

The model was estimated with TSP.

Appendix (7): Data description and construction of the variables

For Pakistan most of the data used in this study were obtained from various issues of the CENSUS OF MANUFACTURING INDUSTRIES and the ECONOMIC SURVEY STATISTICAL SUPPLEMENT: 1987-88, and cover the 1966-1985 period. For Turkey most of the data came from the STATISTICAL YEARBOOK and from unpublished tax data. They cover the period from 1973 to 1986. The construction of the variables was done as follows:

Land and Buildings: The quantities of land and buildings were constructed by dividing the stocks by the investment deflator. The stocks were constructed by employing the perpetual inventory method, with the depreciation rate set equal to 0.05. As starting values for the stocks we used the 1956 end-of-year book values of land and buildings.

Machinery and Equipment: The quantities of machinery and equipment were constructed in the same way as those of the land-and-buildings variable, except that a depreciation rate of 0.10 was used.

Rental prices of the services from physical and knowledge capital: The right-hand sides of equations (15) and (16), and the right-hand sides of equations (27) and (28) were used to calculate the user costs of capital.

Labour: The quantity of labour was measured as the total number of days worked during the year for Pakistan, and as the average number of employees during the year for Turkey. The price index was constructed by dividing total employment cost during the year by the number of days worked (Pakistan) or the number of employees (Turkey).

Intermediate inputs: For Pakistan intermediate inputs include electricity, petroleum fuel, natural gas, and imported and domestically produced miscellaneous materials. Intermediate inputs for Turkey include raw materials, components, containers, fuel and electricity. Aggregate price and quantity indices were constructed from these components by using the Tornqvist approximation of the Divisia index.

Output: The quantity of output was constructed by dividing the total value of output by the manufacturing output deflator.

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